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A REVISION OF THE TUBERALES OF CALIFORNIA

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CONTENTS

I. INTRODUCTION

Of all members of the vegetable kingdom, the longest, perhaps, to remain in absolute obscurity as to their manner of growth and methods of reproduction, were the truffles and their allies. Practically no study had been made of their life-history or relationships until the beginning of the nineteenth century, when four species were described by Persoon in his *Synopsis Fungorum*. Twenty years later, Fries added eight species distributed through four genera. But the first real critical study of these plants was made by Vittadini, who published in 1831 his *Monographia Tuberaceorum* containing in thirteen genera seventy-three species. These pioneer workers were followed by Klotsch, Corda, and by the Tulasne brothers, whose *Fungi Hypogaei* with its twenty-one exquisite plates, appearing in 1851, is still

one of the most valuable contributions which have been made to the subject. Within recent years, Professor Oreste Mattirolo of the University of Turin, Italy; Professor Edward Fischer of Bern, Switzerland; Fedor Bucholtz; Professor Th. M. Fries of the University of Upsala, Sweden, and others, have added to our knowledge of these plants.

All the studies mentioned, however, have been principally of European forms. In Fischer's review of the Tuberales for the *Pflanzenfamilien* in 1897, only one species was reported from North America; and except for the work of Spegazzini in Argentina, and Harkness in California, the hypogaeous fungi of the western hemisphere have been quite neglected. The fact that they are little known in comparison with those of Europe may be accounted for by the supposition that our hypogaeous flora is less rich than that of the other continent; but a more reasonable explanation at present is, perhaps, that attention has not been attracted to them by an overcrowded population necessitating the utilization of every possible natural resource. In any case, material is present in some quantity, for occasional specimens have been reported from New York, Pennsylvania, Louisiana, Minnesota, and Michigan, as well as California, and at least small collections are known to have been made in various other parts of the United States. Much of this material, however, has perhaps been picked up by accident, and no attempt, so far as known, has been made to assemble data for a systematic account of the hypogaei of America.

In 1899, a paper entitled "California Hypogaeous Fungi" was published in the *Proceedings* of the California Academy of Sciences by Dr. H. W. Harkness, a retired physician living at the time in San Francisco. He had long been interested in the neglected fungus flora of the west, and had published, with Justin P. Moore, nine years previously, a catalog of the Pacific Coast fungi. The results of his scientific labors appeared from time to time in *Grevillea*, the *Bulletins* and *Proceedings* of the California Academy of Sciences, and other journals.

Harkness' paper dealing with the hypogaei was received with considerable interest, since it was the first work of its kind in North America. Unfortunately, however, no keys are included, and the descriptions are so abbreviated that one who has not the privilege of access to the type material finds the paper of little value in the placing of unknown plants. In spite of this, much credit is due Dr. Harkness for his pioneer work carried out under various difficulties, in collecting and arranging the species so far as they were known at that time.

II. MATERIALS AND TECHNIQUE

The collection assembled during the twenty-five years that Dr. Harkness studied the fungi of the Pacific Coast is said to have aggregated ten thousand species. Some of these were acquired by purchase or exchange, but the most were native plants of California, the range of territory covered extending from Mount Shasta on the north to Fort Yuma on the south, and from the seashore to the eastern limits of the Sierras (Harkness, 1880, p. 1). Of this collection the greater part became the property of the California Academy of Sciences whose headquarters were in San Francisco. Unfortunately, the herbarium of the Academy was largely destroyed by the fire of 1906, the only specimens of fungi saved being those designated as types of new species, which were rescued with much difficulty and hardship by Miss Alice Eastwood, curator of the herbarium. However, before this time, but after the death of Dr. Harkness, the main collection of hypogaei came into the possession of Leland Stanford Junior University, at Palo Alto, so this portion escaped. Through the kindness of Professor Le Roy Abrams, curator of the herbarium at that institution, full facilities for the examination of the collection were enjoyed. Only three types of the ascomycetous hypogaei are missing. These are not noted on the list of numbers representing the fungi in the California Academy herbarium saved from the fire—for which list I am indebted to Mrs. Katherine Layne Brandegee of the University of California—so it is probable that they are not now in existence.

The Harkness collection consists of "approximately three hundred species," of which nearly one-third are ascomycetous. The specimens are preserved in 95 to 100 per cent alcohol, in bottles, and are labeled, usually, with both numbers and names, though in some cases neither is present. While most of the specimens are Californian, a few are from European herbaria. No data whatever are to be found for the unlabeled material, except a quotation from Dr. Gustav Eisen, the illustrator of the Harkness paper, who believed it to have been collected after the publication of the latter. Of many species little material is present, a number having only a portion of an ascocarp remaining.

In addition to the specimens, there is a large number of slides in the collection. Some of the sections were hand-cut and mounted in glycerine, while the remainder, which were made by microtome, were preserved in balsam. The latter, according to Dr. Eisen, were the

ones used principally for his illustrations. All the slides are, however, at the present time almost worthless. Those in glycerine are unsealed, and consequently suffered seriously during shipment. Those in balsam were less injured, but little remains to be seen of the delicate, colorless fungal tissues. It has been necessary, therefore, with nearly every specimen, to make new sections; and in cases in which only a small part of a type remains, the matter of securing for sectioning a portion from the most desirable location without injuring the value of the remainder of the plant has been a delicate one. Some of the ascocarps are riddled by insect work, which is a particular disadvantage in cases of scanty material.

Another difficulty met in working over the collection has resulted from various confusing discrepancies of numbers and names. In several instances, one species is discovered to have been described under three or four different names; or a plant cited in the *Hypogaeous Fungi of California* as a particular species is found in a bottle bearing a different label. Two young specimens were published under different specific names from the mature plant, one even appearing in a separate genus. Sometimes two species are cited under the same number, and occasional bottles bear two numbers. The solution of such difficulties is rendered more difficult by the very meagre descriptions in the Harkness paper, and by the fact that when a plant was considered identical with a previously described species, the original description was quoted, generally in abridged form, and no critical notes added. The collection as a whole, however, has been found to be in good condition; of some species there is ample material, and it has been possible in most cases to obtain very satisfactory sections.

In addition to the Harkness collection, the hypogaei in the herbarium of the University of California have been available for study. This collection, made principally by Professors W. A. Setchell and N. L. Gardner, numbers at present about four hundred and fifty specimens, of which nearly one hundred are ascomycetous. As a provision against any possible accident or emergency, material of nearly every species is preserved both in dried form and in alcohol. The mistake was made at first of preserving the specimens in formalin, but it was soon discovered that these became too soft to section. Ninety-five per cent alcohol was substituted and the material so preserved retained its original firmness.

Besides the Californian species present in the University collection, there are two species of *Tuber* from Professor Kauffman of the Uni-

versity of Michigan, one from Professor F. Butters of the University of Minnesota, and specimens of a *Tuber* collected by Professor Gardner in Iowa. There has also been available for comparison European material received from Professors Mattirolo of Italy and Fischer of Switzerland. Unfortunately, however, it has been impossible to examine types of European material, and all classifications have depended of necessity upon published descriptions and illustrations.

In preparation for study, alcoholic material was soaked in water for some time, then sectioned by Professor Gardner's adaptation of the Osterhout freezing method of cutting (Osterhout, 1896, p. 195). Sections from 5 to 15μ were made, those of 10μ being found in nearly all cases most satisfactory. The material in formalin was similarly treated, but in every case was too soft to section successfully. The only stain employed was Fuchsin S (Grüblers) in acidified alcohol, which was sufficient clearly to contrast cell walls and contents.

III. DISTRIBUTION IN CALIFORNIA

Of the distribution of hypogaei in California much is yet to be known, for though the field thus far covered by collectors is comparatively broad, the work done has necessarily been more or less desultory. Dr. Harkness (1899, p. 242) bounds the region over which he collected

> on the north by the California State line, on the south by the Tehachapi range, by the sea-coast on the west, and the Valley of Donner lake upon the east—an area exceeding 400 miles from north to south, and some 300 miles from east to west, and within which are to be found the Coast Range mountains, with the dense forests of Sequoias, and the Sierra Nevada mountains rising to an elevation of 8,000 feet.

As to the seasons, he says (pp. 242–243):

> Many species may be found soon after the first autumnal rains, especially if the rain is followed by a period of sunshine and moderate heat. If these conditions continue during the entire rainy season, much material may be collected during the winters. The most productive season, however, is that of early spring, as it seldom fails during these months that there are warm rains followed by sunny days. If, as it sometimes happens, there is an abundant precipitation of moisture, good material may be found even late into the spring. After the close of the rainy season, but little is to be found, unless it be upon the banks of mountain rivulets, or in a few favored spots where there exists sufficient moisture combined with a suitable soil. . . . The earliest date at which we may hope to find *Tubers* (truffles, so-called) is about the first of January. At this time the cell structure of the gleba is in a perfect state, but

is still destitute of asci or spores, which makes the identification of species impossible. So far as I have seen, the spore does not arrive at maturity until April; much, however, depends upon the weather.

Professor Gardner's experience in regard to seasons differs somewhat from the preceding, for he has collected various species of *Tuber* which were fully developed in the early part of December. As Dr. Harkness has stated, however, much depends upon the weather, and the years of early *Tubers* correspond to those in which early and frequent rains are followed by warm sunshine.

The trees and shrubs which Dr. Harkness cites as associates of ascomycetous forms are: *Quercus, Pinus, Abies, Sequoia, Libocedrus, Ceanothus, Eucalyptus, Arctostaphylos,* and *Heteromeles.* Professor Gardner adds *Arbutus* and *Salix* to the list. In few cases was a fungus discovered always to be associated with the same kind of tree or shrub, some species even being found under various conifers as well as deciduous trees.

Many species, according to Professor Gardner, grow only under leaves, while some are truly hypogaeous and occur sometimes several inches under ground. The soil may be light and porous, or may be of heavy clay. The latter is evidently preferred by *Tuber candidum,* which is often found buried two or three inches deep. It is reported also, however, as growing in both leaf-mold and sand.

IV. ECONOMIC IMPORTANCE

Dr. Harkness states (1899, p. 244): "All of the Californian species are . . edible, and no doubt would be greatly esteemed as a luxury were it not for the fact that they are so rare as to practically prohibit their use as food." On the same page he refers to a species which a number of years ago was discovered in large quantities near Marysville and Sacramento. It was freely eaten and considered a great delicacy; and from its large size and its effect upon the surface of the ground above it, Dr. Harkness, who knew it only by report, believed it to be a species of *Terfezia,* a genus well known in Southern Europe and Western Asia for its edible qualities. Unfortunately, no further notes have been made, and whether or not a *Terfezia* exists in California is still unknown.

Professor Gardner has found *Tuber candidum, T. californicum,* and *Geopora Harknessii* in comparative abundance, but no particular

tests of their edibility have been made. At present writing, however, specimens of *Geopora magnifica*, a large species measuring from four to ten centimeters in diameter, have been sent in from Alameda, California, the discoverer, Mr. A. A. Baroteau, having for some time collected and eaten the plant and esteemed it as an article of food.

Of the true *Tubers* found in our state, none are closely related to the common edible truffles of Europe. *Tuber aestivum* of England, *T. brumale* of France, *T. magnatum* of Italy, and others, all so-called "black" or "queen" truffles, are dark brown or black, with the surface covered by large pyramidal or shield-shaped warts. The "white" truffles of Europe are lighter-colored, with a smooth, or at most a verrucose surface; and while some of these are eaten, they are in much less demand than the former. The *Tubers* thus far reported from California are all "white" truffles, but apparently even of these we have none of the European species. None of our species exhibits any marked odor, and since the truffle is used as a condiment and valued for its flavor rather than for any nutritive value it may possess, it is probable that ours will not prove of great economic importance.

V. MORPHOLOGY AND PHYLOGENY

Owing to the difficulties in the way of securing early stages in the life-history of hypogaeous fungi, the relationships of the various genera with each other and with other orders is still largely a matter of conjecture. The latest arrangements of the ascomycetous forms are those of Fischer (1897*a*, p. 279; 1908, pp. 142–161), and Bucholtz (1903, pp. 161–164). It will be seen from the text of all three that the arrangements have been based principally upon the structure of mature ascocarps rather than upon development. In a few species moderately young ascocarps were studied, *Tuber excavatum* and *T. puberulum* by Bucholtz (1903, pp. 154–158), and *Piersonia bispora* (the species at that time unnamed) by Fischer (1908, pp. 149–154). The latter also figures in Rabenhorst's *Kryptogamen-Flora von Deutschland* (V Abtheilung, p. 8) an immature ascocarp of *Genea sphaerica*. No statement is found concerning the age of the specimen from which the drawing was made, and the fact that no notes in regard to development accompany the illustration, except one refering to the width of the apical opening, would perhaps indicate that the ascocarp was too nearly mature to reveal much of value in the way of changes

due to growth. Bucholtz makes the statement that ascocarp development in *Genea* is wholly unknown (1903, p. 163). Fischer quotes Mattirolo as saying that he has examined young material of *Balsamia* and has concluded that the latter is cleistocarpous in origin (Fischer, 1908, p. 159). I have not yet had an opportunity of consulting the original reference as to the extent of Mattirolo's study of this genus.

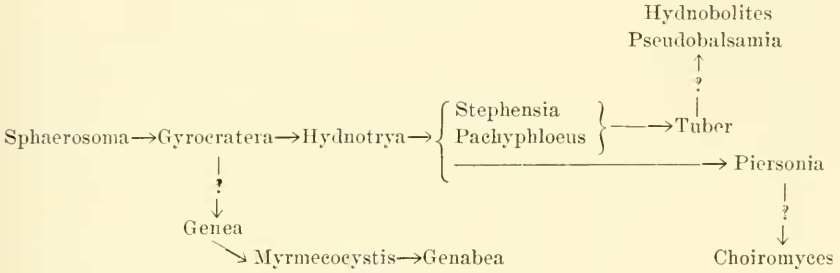
These observations, with those of De Bary and Solms-Laubach, represent practically all cases, so far as I have been able to discover, of inquiry into the development of the ascomycetous hypogaei. In no case have I found record of observations upon the entire life-history of any species.

In Engler and Prantl's *Die natürlichen Pflanzenfamilien,* Fischer included the ascomycetous hypogaei under two orders—Tuberineae Winter (Tuberales) and Plectascineae Schröter (Plectascales), basing the division upon the presence and absence, respectively, of definite hymenium, and the consequent massing in the latter case of the asci in definite areas. However, the distinction between the two orders, which were considered of different origin but of parallel development, is so obscure that Fischer has since transferred several genera from the Plectascales to the Tuberales, principally upon their resemblance, apparently, to newly-investigated genera which he considers undoubted Tuberales (Fischer, 1908, p. 160). In the opinion of various botanists the presence or absence of a defined hymenium is not sufficient basis for a separation into two orders, and the status of the Plectascales is at present somewhat uncertain.

The Tuberales in *Die natürlichen Pflanzenfamilien* were divided into two families, Eutuberaceae and Balsamiaceae, also considered of different origin but of parallel development. The Eutuberaceae, including all genera having openings from the hymenium to the exterior of the ascocarp, were placed in phylogenetic line with the gymnocarpous Helvellales; while the Balsamiaceae with closed ascocarps were considered descendants of the hemiangiocarpous Pezizales. Under Balsamiaceae were placed *Balsamia, Geopora,* and *Hydnocystis* (the latter two with some doubt); and the Eutuberaceae included *Genea, Pseudhydnotrya, Hydnotrya, Stephensia, Pachyphlocus,* and *Tuber.* In the *Botanische Zeitung* (1908) Fischer again published an opinion of the relationship of these plants, and his arrangement of the genera at this time, which was largely influenced by investigations of Californian forms, varied in several important points from the original. *Pseudhydnotrya* Fischer, which had formerly appeared under Eutuberaceae

because external openings had been observed, was reduced, the genus being considered identical with Geopora, originally of the Balsamiaceae. The latter family was left with the single genus *Balsamia*, its relation to *Geopora* and *Hydnocystis* being questioned. To the Eutuberaceae were added the new genera *Gyrocratera*, *Pseudobalsamia*, *Piersonia* and *Myrmecocystis*, as well as the genera *Hydnobolites*, *Choiromyces*, and *Genabea*, which were earlier included with the Plectascales.

Fischer's arrangement for the Eutuberales, which is essentially, with some modifications and additions, that of Bucholtz, is represented in the following table:



The Eutuberaceae are connected with the Helvellales by *Sphaerosoma*. The status of the latter genus has been discussed by Setchell (1910), who proves that *Sphaerosoma* Klotzsch belongs to the Pezizales rather than to the Helvellales. Fischer may have referred here to *Sphaerozone ostiolatum* (Tul.) Setchell, which was named *Sphaerosoma ostiolatum* by Tulasne, and which is probably a member of the Helvellales. Tulasne's figures of this species were used by Schröter in the Pflanzenfamilien (p. 172) under the name *Sphaerosoma fuscescens* Klotzsch.

In the diagrammatic table, plate 26, I have shown an outline of the relationships of the genera which I have had opportunity to observe, as I understand these relationships at the present time. It will be noticed that several genera mentioned by Fischer are absent. Of these *Gyrocratera* and *Genabea* have been omitted because no material has been at hand for study, while *Myrmecocystis* is included as a subgenus under *Genea*, the reasons for its reduction being found in the discussion of that genus. *Delastria* and *Terfezia* have been transferred from the Plectascales, tentatively, at least, for the presence or absence of definite hymenium does not seem sufficient to separate them so widely from

the genera of the Tuberales which they resemble in general character, habit, and habitat, more closely than genera of any other order.

This arrangement, like all preceding arrangements, has been based principally upon a study of mature ascocarps. In only one case, that of *Tuber candidum*, were young plants available for investigation, but these served rather to strengthen than weaken the probability of the relationships indicated in plate 26.

In the following explanation of the table, it is hoped that the linking of the Tuberales with the Pezizales, and the further theory of relationships indicated, will be justified so far as justification of any arrangement is possible with our present imperfect knowledge of development in these plants.

Except for the absence of localized mycelium in *Hydnocystis*, there is little difference between this genus and *Peziza*, either in superficial characters or fundamental structure. The latter exists first as a completely closed body which opens during development as a result of more rapid internal than external growth, the hymenium for the first time becoming exposed. *Peziza*, then, is of angiocarpous origin. Both *Hydnocystis* and *Genea* also appear sometimes as closed bodies, and while the earliest stages are not known, it is not unreasonable to assume that these genera, too, are originally angiocarpous, the open forms representing cases of greater inequality of growth in cortical and subcortical tissues. An interesting point here, which may or may not be significant, is the presence in many genera of the Pezizales of branched paraphyses similar to those found in several species of *Genea;* and even the secondary cortex of the latter is, to an extent, duplicated in *Conida*, *Caldesia*, *Heteropatella*, and other members of the above-named order.

In plate 26, two main lines of development labeled respectively *A* and *B* are indicated, the ascocarps of the former differing from those of the latter in the possession of external openings from the hymenium. This condition is first observed in *Hydnocystis* in which, apparently, the subcortical growth has exceeded the cortical in certain forms. Others remain completely closed and give rise to the genera of line *B*. In *Geopora* the comparatively simple ascocarp form of *Hydnocystis* has become complicated by greater disparity of growth in the two tissues, causing infoldings of the entire wall, and inward-extending projections from the inner surface. In a few cases here also is found such great disparity of tissue development that the cortex has yielded to the pressure from within, and openings are formed. As

the simple cavity of the ascocarp becomes filled with folds of tissue, it is dissected into canals of various form. These are first represented in *Geopora,* and continue through the line. These canals are generally lined with a palisade of asci and paraphyses, some of the latter at times developing into the canals and filling them with a mass of branched and tangled hyphae. Such canals are called *venae externae* and are seen in *Pseudobalsamia, Stephensia, Pachyphloeus, Tuber,* and *Piersonia.* In other cases the paraphyses all remain as palisade or are absent, and the passages are left free, as in *Geopora* and *Hydnotrya.*

As the ascocarp becomes more and more crowded with minute, irregular folds of tissue, these are fitted together until the hymenium loses all indication of order; and the asci are massed in apparently irregular form in areas separated by narrow veins, the latter representing the original folds or projections which were large enough to retain their identity. This is the condition found in *Tuber.* In *Piersonia* the internal folding has not been so great, but the hymenial areas are distinct, through the loss of asci for long distances upon the venae externae, and the consequent shrinkage of the latter, forming narrow canals.

Line *B* branches from the original with the definite appearance in *Balsamia* of closed chambers. These are first to be considered in *Geopora,* in which various folds coalesce, closing the passages. These chambers become complicated in *Hydnotryopsis* by infolding of their walls, producing a condition in each chamber similar to that of the original cavity of *Geopora.* In *Choiromyces* the open canals of *Hydnotryopsis* become filled with hyphae formed by development of paraphyses; and finally in *Terfezia* and *Delastria* all semblance of order in the hymenium is lost, as in *Tuber.*

These lines which were arranged merely upon ascocarp structure, were found to exhibit development in spore characters and numbers as well. For example, *Hydnocystis* has spores which are entirely smooth, and this character continues through the genera to *Pachyphloeus* of the one line and *Hydnotryopsis* of the other. In the offshoot *Genea,* however, sculptured spores are observed. The asci of all genera to *Tuber* and *Delastria* contain generally eight spores, from this point the number varying through one to four.

Several points of the preceding theoretical line of development of the Tuberales have been borne out to some extent in a study of these plants. (1) In *Geopora Harkuessii* every stage was found between

an almost simple ascocarp and one having the cavity dissected into complex canals with the walls more or less coalesced to form closed chambers. *G. magnifica* represented the highest development in this genus of the latter condition; and occasional openings, apparently due to growth, were found in both species. (2) The very close similarity of form and structure between *Balsamia* and *Pseudobalsamia*, described under the latter genus, seems to indicate a nearer relationship than that attributed to them by Fischer. (3) Fascicled paraphyses and occasional undeveloped asci in the sterile canals of *Piersonia* denote the possible disappearance, mentioned above, of asci from these parts, and the resultant closing together to form the very narrow channels leading to the hymenial areas. (4) The actual condition was found in young ascocarps of *Tuber candidum* in which folds of tissue of varying size and shape from the subcortex were projected into the cavity and became fitted so closely together that all trace of the original folds as such was lost. The walls were covered with a hymenial palisade of asci and paraphyses, which was perfectly regular except for a rare ascus which had apparently been too crowded in development and had not been able to parallel in position the other asci. At first the whole cavity of the ascocarp was apparently in communication, but as the various folds and projections of irregular form became fitted together, many of the paraphyses developed into the canals, filling them with tangled hyphae which became more or less compressed, and the original system was finally hidden in the mass of tissue, asci, and spores. The wider canals did not lose their identity but remained as venae externae. The venae internae in this case were clearly the original folds or projections, and not simply compressed layers of tissue taking the form of veins between developing asci, as they have generally been understood in other species.

The material was not sufficiently young to show the complete development of the external openings, but so far as observed the ascocarp did not appear to have the gymnocarpous origin which Bucholtz (1903, pp. 154–158) believed he had discovered for *Tuber*. Further studies of young ascocarps, however, are expected to throw more light upon this point.

VI. SYNOPSIS OF REVISION

The changes made in the arrangement of species found in the Harkness paper are indicated in the list which follows.

Species Cited by Harkness:	Referred to:
Balsamia alba	Pseudobalsamia magnata
filamentosa	
magnata	
platyspora	
polysperma	
vulgaris	
Balsamia nigrens	Pseudobalsamia magnata, var. nigrens
Choiromyces gangliformis	Pachyphloeus citrinus
Delastria rosea	Delastria rosea
Genea arenaria	Genea arenaria
compacta	compacta
hispidula	Harknessii
sphaerica	Gardnerii
verrucosa	Harknessii
Geopora brunneola	Geopora annulata
Cooperi	Not found
magnata	Not found
mesenterica	Not found
Hydnobolites excavatum	Piersonia alveolata
Hydnocystis compacta	Genea intermedia
Hydnotrya cerebriformis	Hydnotrya cerebriformis
Myrmecocystis candida	Myrmecocystis cerebriformis
Myrmecocystis cerebriformis	Myrmecocystis cerebriformis
Pachyphloeus carneus	Pachyphloeus citrinus
Pachyphloeus ligericus	Piersonia alveolata
Piersonia alveolata	Piersonia alveolata
scabrosa	Piersonia alveolata
Pseudhydnotrya carnea	Geopora Harknessii
Harknessii	
nigra	
Stephensia bombycina	Hydnotryopsis Setchellii
Terfezia spinosa	Terfezia spinosa
Zeynebiae	Zeynebiae
Terfeziopsis lignaria	Tuber lignarium
Tuber australe	australe
Borchii	levissimum
candidum	candidum
californicum	californicum
Caroli	candidum
citrinum	citrinum
Eisenii	candidum
excavatum	separans
gibbosum	gibbosum
Magnatum	californicum
monticolum	monticolum
olivaceum	candidum
puberulum	californicum

VII. SPECIAL MORPHOLOGY AND TAXONOMY

In the following pages the structure of each specimen examined is considered in detail. In certain cases descriptions are necessarily somewhat incomplete, through lack of sufficient data and material This is particularly true in several specimens of which little remains in the Harkness collection, for such characters in these cases as color, size, and shape cannot be determined with accuracy.

It will be found in the taxonomic arrangement which follows that a number of new names have been proposed, very few of our species being referred to European forms. Even the latter have been so referred with some doubt, for the specimens of the one and descriptions of the other do not entirely agree, and the inability to make comparisons with European material renders the matter still more uncertain. In general, particular species of the Tuberales do not seem to be represented in both the eastern and western hemispheres, though apparently closely related species are found.

Throughout the following descriptions, spore measurements in every case have included sculpturing. This has not been customary in certain genera, for example *Tuber,* but it was found impossible to measure the main body of most spores having a thick, deeply colored epispore. In order to avoid confusion, therefore, all measurements were made in the same way. However, in all possible cases in which such addition seems necessary, the thickness of the sculpturing is also cited.

Hydnocystis Tul.

Ascocarp even or somewhat lobed, hollow, subglobose, with or without external opening from hymenium, opening when present often more or less closed by dense hairs; surface verrucose, covered with short or long hairs; tissue of ascocarp wall partly or entirely pseudoparenchymatous; cavity of ascocarp lined with hymenium consisting of asci and paraphyses in palisade; asci cylindrical to long clubshaped, rounded at end; paraphyses slender, length of asci or projecting beyond them into interior of ascocarp; spores globose to globose-ellipsoid, smooth, colorless or of very light color.

The structure of the ascocarp in this genus is very similar to that in many of the Pezizales; and in the *Hydnocystis* species which open, the plant much resembles an inverted *Peziza.* Apparently there is no

record of studies made of young forms in this genus, but it seems evident from mature ascocarps that, as in *Peziza*, the opening from the hymenium comes about as the result of development. Considering these resemblances, as well as those of *Hydnocystis* to *Geopora* and through the line to *Tuber* and *Piersonia*—described in the introduction to this paper—its arrangement as a connecting link between the Pezizales and the higher Tuberales seems justifiable.

Hydnocystis californica sp. nov.

Plate 29, fig. 9

Ascocarp 1 cm., subglobose, light to very dark brown, completely closed, enveloped in brown, septate, branched mycelium; surface divided into mostly hexagonal areas, 1.5 mm. in diam., forming bases of pyramidal projections; gleba white; tissue pseudoparenchymatous through verrucosities, cells 12–16μ in diam., walls of outer cells slightly thickened; occasional cells developing as septate hairs; pseudoparenchymatous tissue changing within to hyphae of same diam. as outer cells, these becoming much narrower toward hymenium; latter lining cavity of ascocarp and formed of regular palisade of asci and paraphyses; asci cylindrical, somewhat constricted between spores, narrowing to more or less definite stipe, 16–24 $\times$ 240μ; spores globose-ellipsoid, smooth, 18–20 $\times$ 22–24μ, 1-seriate; paraphyses slender, 4–6μ thick, generally length of asci but some projecting beyond at irregular distances; barely swollen at tip.

Odor of caramel.

"Under *Pinus*, in sand, Ingleside, San Francisco Co., Cal., May 2, 1903." No. 127, U. C. Col., *type*. N. L. Gardner.

The three species of *Hydnocystis* described in *Sylloge Fungorum*, vol. VIII, p. 876, are distinguished from our species as follows:

H. piligera by globose spores 32–35μ in diam.;

H. arenaria by an opening to hymenium, size of ascocarp (reaching the diameter of a chestnut), spore measurement (13–16 by 16–19μ), and unpronounced odor;

H. Thwaitesii by an opening to the hymenium, and spore shape and measurements (13–16 by 16–19μ).

There are other minor differences and all seem sufficient to separate the species.

H. Beccari, a later species founded by Mattirolo, apparently differs from ours in long-ellipsoid spores (24–27 by 15μ) and the presence of an opening to the hymenium, though full descriptions of this species could not be obtained.

Pseudobalsamia Fischer

Ascocarp subglobose to more or less depressed, somewhat lobed, infolded at apex, point of attachment of mycelial tuft at base more or less distinct; surface verrucose; outer cortical tissue pseudoparenchymatous; venae externae forming irregular canals filled with hyphae or open, converging toward apex and opening to surface at one point or several points; asci 8-spored, globose-ellipsoid, deformed by crowded spores, stipitate, irregularly arranged between veins; spores smooth, hyaline, ellipsoid, irregularly arranged in asci.

A mycelial tuft at the base is not always present, but when absent it has probably disappeared at maturity or upon collection, for a more or less definite point of original attachment is generally visible, usually with slightly elongated lobes of the ascocarp radiating from it.

Fischer, who described this genus from Californian material collected by Professor N. L. Gardner and sent by Professor W. A. Setchell, places *Balsamia* Vitt. and *Pseudobalsamia* in different lines of development, and bases this arrangement upon the presence in the latter of venae externae and the absence of conspicuous venae internae (1908, pp. 154–156). However, in the material of *Pseudobalsamia* which I have studied there is a layer of hyphal tissue below the pseudoparenchymatous cortex, which can be traced for a short distance into the gleba, parallel to the venae externae, and giving rise to the asci. In some plants this layer is much more definite than in others, but in all plants observed it can easily be found. It is not distinguishable throughout the gleba, as it is in an Italian specimen in the University of California herbarium, received from Mattirolo and labeled *B. vulgaris,* and the asci are therefore somewhat more irregularly placed, but in *Pseudobalsamia* the free ends of the asci lying nearest the canal are turned toward it as in Balsamia, showing a degree of the more or less definite arrangement found in the latter.

A little farther on in the article above mentioned (1908, pp. 154–156), in placing *Pseudobalsamia* in phylogenetic line with *Tuber,* Fischer makes the statement that the absence of "venae internae" is not so important as it might at first glance seem, for the reason that in several species of *Tuber* they are little developed. He quotes in this connection the following sentence from Bucholtz in regard to *T. puberulum* (Bucholtz, 1903, pp. 152–174): "Durch Bildung von Asci wird das ursprünglich lockere Geflecht im Innern des Fruchtkörpers zusammengedrückt und in die hier äusserst schwachen, manchmal gar

nicht entwickelten Venae internae verwandelt." *Pseudobalsamia*, as I have seen it, agrees with Fischer's description of *Balsamia* (1897*a*, p. 62), in the following points: Ascocarp knob-like, fleshy, with or without basal mycelial tuft; penetrated by numerous labyrinthine chambers (open in *Pseudobalsamia*); peridium consisting of outer layer of pseudoparenchyma and inner layer of closely woven hyphae, this layer continuing into the chamber walls as trama (venae internae); chambers clothed with ascus-bearing zone consisting of paraphyses arranged in more or less distinct palisade; asci of more or less unlike form, often irregularly globose or ellipsoid, often long stipitate, 8-spored; spores ellipsoid or almost cylindrical with rounded ends, smooth, placed irregularly in ascus.

The asci do not appear to lie between the paraphyses as they are described for *Balsamia*, for the paraphyses are always developed above them, but, as previously stated, the fact that the outer layer of asci, *i.e.*, the ones nearest the venae externae, have their free ends turned toward the canal, would indicate a similar fundamental arrangement. In the genus *Hydnotrya* there is apparently as much irregularity in the arrangement of asci as in these two genera, for they are described by Fischer (1907, p. 26) as "palissadenförmig zwischen den Paraphysen stehend oder ausserdem noch unregelmässig in dem darunterliegenden Geflechte eingebettet."

The "hollow" chambers of *Balsamia* (Fischer, 1897*a*, p. 62) apparently do not hold for *B. platyspora* Berk. which is said (*ibid.*, p. 65) to possess "oft durch Hineinwachsen der Paraphysen ausgefüllten Kammern." The occasional presence, then, in the chambers of *Balsamia* of hyphal structure, and the occasional absence of the same in the chambers of *Pseudobalsamia* (see preceding description), show that no distinct point of difference can be found here.

Since *Pseudobalsamia*, as I have studied it, agrees with Fischer's description of *Balsamia* in practically every respect except the presence of venae externae and the absence of completely developed venae internae; and since, according to Fischer, the latter character is unimportant, a complete separation of the two into distinct phylogenetic lines seems unjustifiable without definite evidence that the differences are due to origin rather than development. *Hydnobolites*, near to which *Pseudobalsamia* belongs according to Fischer (1908, pp. 155–156), is distinguished from it by globose sculptured spores, pseudoparenchymatous lining of canals (the latter always hollow), and complete lack of venae internae. These would seem more nearly to ap-

proach fundamental differences than those separating *Balsamia* and *Pseudobalsamia*. A thorough study of young ascocarps, however, will be necessary to determine the actual relationships existing among these various genera.

Pseudobalsamia magnata (Hk.) comb. nov.

Pseudobalsamia Setchellii Fischer, Ber. deutsch. Bot, Gesell., 1907, p. 374; Bot. Zeit., 1908, pp. 154–156, pl Vi, figs. 11–13.

Balsamia magnata Hk., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, No. 8 (1899), p. 264.

Balsamia alba Hk., Proc Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, p. 264.

Balsamia filamentosa Hk., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, p. 265, pl. XLIII, figs. 13*a*–13*f*.

Balsamia vulgaris Hk. non Vitt., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, p. 265.

Balsamia platyspora Hk. non Berk., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, p. 265.

Balsamia polysperma Hk. non Vitt., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, p. 265.

Ascocarp orange to reddish brown, 1–2 cm. in diam., somewhat depressed globose, infolded at apex, with more or less persistent mycelial tuft at base; surface of ascocarp divided into distinct polygonal areas forming bases of more or less pointed verrucosities; tissue of latter pseudoparenchymatous, generally thick-walled throughout, cells becoming smaller and walls thinner, changing gradually to hyphal tissue below verrucosities; outer cells of cortex often extended to form simple hairs, particularly at openings of venae externae, hairs continuing inward, as elongations of paraphyses forming hyphal filling of canals; interior of ascocarp formed of closely crowded folds of tissue, often united, separating labyrinthine canals or sometimes apparently closed chambers; inner walls of these lined with asci and paraphyses; canals and chambers filled with hyphae (formed by elongation of paraphyses), or completely open; canals converging at one point or at several points, opening to exterior through infolded apex of ascocarp; asci irregularly arranged between canals with free ends of those lying nearest canals turned toward latter; asci generally short-stipitate, more or less globose-ellipsoid, but usually much deformed by irregular arrangement and crowding of spores, 25–35 by 50–70μ; spores smooth, colorless, varying in single plant from long cylindrical with rounded ends to globose-ellipsoid, 12 by 24 to 14 by 22μ, usually with three oil drops; paraphyses irregular in shape, 4 to 6μ wide, quite regularly arranged in palisade, some elongated and branched, forming loose hyphal tissue of canals.

"In forests, Auburn, Placer Co., Calif., May."
No. 185, Hk. Col. *Type.*
"Under oaks, Wire Bridge, Placer Co., Calif., Feb."
No. 129, Hk. Col. *Type* of *B. alba.*
"Under *Heteromeles arbutifolia*, Auburn, Placer Co., Calif., Feb."
No. 236, Hk. Col. *Type* of *B. filamentosa.*
"Among decaying vegetation in shrubby thickets, Auburn, Placer Co., Calif., Dec." No. 231, Hk. Col. Referred to *B. vulgaris.*
"Among shrubs under vegetable mold, Auburn, Placer Co., Calif., Dec." No. 222, Hk. Col. Referred to *B. platyspora.*
"Under shrubs in sandy soil, Auburn, Placer Co., Calif., Dec."
No. 220b, Hk. Col. Referred to *B. polysperma.*
"In soil under *Ceanothus*, Mill Valley, Marin Co., Calif., Dec. 28, 1902." No. 33, U. C. Col. W. A. Setchell and C. C. Dobie.
"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Jan. 3, 1903." "Under *Pinus*, Apr. 1." "Under *Pinus radiata*, Mill Valley Calif., Jan. 23, 1904." No. 46, U. C. Col. N. L. Gardner.
"Hypogaeous under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Nov. 19, 1904." "Under *Arbutus Menziesii*, Mill Valley, Calif., Mar. 8, 1905."
No. 212, U. C. Col. *Type* of *P. Setchellii.* N. L. Gardner.
"Under *Ceanothus sorediatus* in sand, near Golden Gate Park, San Francisco, Calif., Mar. 23, 1905."
No. 280, U. C. Col. N. L. Gardner.
"Ingleside, San Francisco Co., Calif., Feb. 13, 1915."
No. 404, U. C. Col. N. L. Gardner.

Very noticeable variation is found in this species in color; degree of verrucosity of surface; thickness of walls and extent of elongation of cortical cells; contrast between cortical and subcortical tissues; and spore size and shape. Yet none of these are sufficiently defined and constant to be used as specific characters. It was evidently upon these characters that Harkness based his various species, but they must be considered, I believe, merely individual differences; for every degree of variation, particularly in cell-form and in shape of spore, sometimes exists in a single plant. Colors range, according to Harkness, from dirty white through orange and brown to black. However, the plant in the Harkness collection labeled *Balsamia alba* is apparently immature, which may account for its absence of color; while the species *B. nigra* appears sufficiently distinct in structure to be considered a variety of *P. magnata.* This leaves the general range of color for the species extending through orange to reddish brown, a variation which is not uncommon in a single species of other genera.

Pseudobalsamia magnata, var. **nigrens** (Hk.) comb. nov.

Plate 30, fig. 33

Balsamia nigrens Hk., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8 (1899), p. 264.

Ascocarp black, somewhat depressed globose, coarsely and sharply verrucose; pseudoparenchymatous cortical tissue divided into two distinct layers, outer cells dark and very thick-walled, inner lighter-colored and thinner-walled, strongly elongated toward center of ascocarp, becoming smaller below but changing rather abruptly to hyphal tissue of subcortex; venae externae narrow, closely filled with interwoven hyphae, opening to surface between verrucosities, the hyphae continuing outward as irregular simple hairs found only at external openings of veins.

"Beneath *Ceanothus*, Auburn, Placer Co., Calif., May."
No. 180, Hk. Col. *Type* of *B. nigrens.*

The color, sharply defined verrucosities, very much thickened walls of outer cortex, strongly elongated cells of inner cortex, and narrow completely filled venae externae, easily distinguish this variety from the type of the species. In the exceedingly variable specimens of *Pseudobalsamia magnata*, however, intermediate forms of all the above characters are found in greater or lesser degree, never so sharply defined as here but sufficiently marked to make a separation of a distinct species in this case unjustifiable.

Pachyphloeus, Tul.

Ascocarp subglobose, with conspicuous basal mycelial tuft; surface pseudoparenchymatous; venae internae originating from subcortical tissue, either at base of ascocarp and extending to various points of upper side, or at different points of periphery and converging at apex; venae internae separated by venae externae, latter opening at various points of upper side of ascocarp or (usually) at single point (generally at apex), in depression; venae externae lined with hymenium, composed of asci and paraphyses in irregular palisade; asci cylindrical or club-shaped, 8-spored; spores globose, acutely or obtusely spinose, regularly seriate or irregularly arranged in ascus.

Pachyphloeus citrinus Berk. et Broome

Plate 30, fig. 24

Ann. and Mag. of Nat. Hist., XVIII, 79.

Pachyphloeus carneus Hk., Proc. Cal. Acad. Sci., 3rd ser., vol. 1, no. 8, (1899), p. 268, pl. XLV, figs. 33*a*–33*b*.

Choiromyces gangliformis Hk. non Vitt., Proc. Cal. Acad. Sci., 3rd ser., vol 1, no. 8, p. 277.

Ascocarp bright orange, 1–3 cm. in diam., somewhat compressed, even, with large, round opening at apex; mycelial tuft at base; surface divided into somewhat elongated polygons 1.5–3 mm. in length, forming bases of low pyramidal verrucosities, each separated into several parts by fissures extending from apex to near periphery; venae externae originating at various points of interior of ascocarp, and converging at apical mouth; cortical tissue pseudoparenchymatous through verrucosities of surface; subcortex mostly hyphal but partly pseudoparenchymatous; venae internae large, little-branched, originating from subcortex and likewise both hyphal and pseudoparenchymatous; asci narrowly club-shaped to very broad, 32–36 by 60–160μ; spores generally irregularly arranged, rarely 1– or 2–seriate, globose 18–22μ; sculpturing somewhat variable, generally consisting of minute, low, comparatively broad, truncate papillae, thickened at tips; occasional spore with projections more or less needle-like; paraphyses 8–13μ thick, rounded and somewhat swollen at end, usually extending beyond asci.

"Beneath *Sequoias*, Mill Valley, Marin Co., Calif., July."
No. 253, Hk. Col. *Type* of *P. carneus*.
"Under *Arctostaphylos*, Calistoga, Napa Co., Calif., April."
No. 151, Hk. Col. Referred to *Choiromyces gangliformis*.
"U. C. Campus, Berkeley, Calif., Jan. 7, 1905." "Under *Arbutus Menziesii*, Mill Valley, Calif., Mar. 8, 1905." "Under *Quercus agrifolia*, Wild Cat Canyon, Berkeley, Calif., Apr. 1, 1905." "Under *Quercus agrifolia*, Berkeley, Calif., Apr. 29, 1905." "Under *Quercus agrifolia*, Berkeley, Calif., May 11, 1905."
No. 251, U. C. Col. N. L. Gardner.

This species is referred with some doubt to *Pachyphloeus citrinus*, for while in general it corresponds with the descriptions of the latter, even to the peculiar sculpturing of the spore, there are several points with which it does not agree. Our plants reach a larger size than that cited for *P. citrinus*, and while the European species is described as dark brown with yellow papillae, ours is a bright orange-color over the entire surface. However, Fischer, who compared a specimen of ours with the type of *P. citrinus*, pronounced the two identical (Letter of October 6, 1905).

In the different specimens of the considerable collection of these plants in the University of California herbarium, little variation is found in characters. Both specimens in the Harkness collection, however, *i.e.*, Nos. 253 and 151, exhibit in cross-section decided lateral compression of the cortical cells, which is not present in the former specimens. No. 151 is immature, with the spores not quite fully developed, and both of the Harkness plants seem somewhat more delicate in structure than those of the University of California collection.

The compression has perhaps occurred in the process of sectioning, as a result of thinner walls due perhaps to younger or less robust condition or to something connected with the method of collection or preservation. In any case, the plants appear identical in all other respects, and this single dissimilarity has not seemed of sufficient importance to separate them.

While a specimen of this species is found in the Harkness collection under No. 151 referred to *Choiromyces gangliformis* Vitt. (Hk. 1899, p. 277), it is probable that this is not the plant which Harkness had under consideration, for there is no possible means of reconciling it with the description he quotes of Vittadini's species, even through the first three adjectives: "Globosus, levis, fuscus." If the original and the present No. 151 are not identical, the locality quoted above for that number is probably incorrect. Here, as in all other such cases, critical notes added by Harkness would be of much value.

Genea Vitt.

Ascocarp verrucose, brown or black, globular or irregular in form, with a variously shaped opening at apex; cavernous, either with large simple hollow or with connected labyrinthine canals formed by infolding of, or inward extending projections from, wall; canals converging at apical opening. Asci and paraphyses arranged in palisade on inner side of wall. Hymenium rarely interrupted by strands of sterile tissue, or conspicuously divided by such strands into "pockets." Paraphyses slender, septate, uniting above asci to form secondary cortex, latter generally narrower and somewhat more finely verrucose than outer cortex, but similar in color and in pseudoparenchymatous structure. Asci more or less regularly cylindrical, 8-spored. Spores ellipsoid or globular, papillose, verrucose, or spinose. 1– or incompletely 2–seriate, colored or colorless.

The genus *Myrmecocystis* established by Harkness (1899, p. 269), and further described by Fischer (1908, pp. 144–149), was originally separated from *Genea* by the light color of the ascocarp; spore sculpturing, shape, and size; and division of the hymenium into definite areas. Several Californian species, however, show such distinctly intermediate forms of certain of these characters that their location under the original arrangement is impossible. *G. Gardneri* and *G. Harknessii*, for example, exhibit as definite division of the hymenium as *Myrmecocystis cerebriformis*, while all other characters are typical of *Genea*. Again, the compact arrangement of asci and fascicled paraphyses, as well as the very large globose spores (36μ), of *G. intermedia*

would place it under *Myrmecocystis;* but the color of the ascocarp, sculpturing of the spores, and grouping of the asci are intermediate between *Myrmecocystis* and *Genea.* The two genera agree in being verrucose, more or less irregular in form, cavernous with a variously shaped opening at apex, asci and paraphyses forming palisade on inner side of wall, with paraphyses extending beyond asci to form secondary cortex. The principal point of difference apparently is in the presence in *Genea* of a mycelial tuft at the base, and its absence in *Myrmecocystis;* but this difference is noticed among the species in other genera of the Tuberales, e.g., *Balsamia* (Fischer, 1897*a*, p. 62). Since the similarity of the two is so marked, and various intermediate forms exist, a separation of the genera not only seems unnecessary but is impossible upon the old basis; therefore, in order to accommodate the previously mentioned forms, the two genera have been united in this paper.

Eugenea subgen. nov. Spores ellipsoid; asci not crowded; hymenium rarely interrupted by strands of sterile tissue.

Spores 28 by 36μ, covered by large, irregular (in size and shape) papillae. ..... *G. compacta.*

Spores 22 by 32μ, minutely and obtusely verrucose ..... *G. arenaria.*

Heterogenea subgen. nov. Spores ellipsoid to nearly globose, asci not crowded; hymenium interrupted by strands of sterile tissue.

Spores 22 by 28μ, covered with papillae varying in size, regularity of outline, and number ..... *G. Harknessii.*

Spores 28 by 32μ, coarsely papillose, papillae more or less covered by very minute papillae ..... *G. Gardneri.*

Myrmecocystis subgen. nov. Spores globose, 28–38μ, papillose or minutely spinose; asci crowded with paraphyses apparently fascicled between; hymenium interrupted by strands of sterile tissue.

Spores irregularly papillose ..... *G. intermedia.*

Spores minutely and densely spinose, spines often coalescing into irregular groups ..... *G. cerebriformis.*

Genea compacta Hk.

Plate 30, fig. 32

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, 1899, p. 262, plate XLIII, figs. 10*a*–10*c*.

Ascocarp light brown; 7–10 cm. in diam., flattened, lobed, surface quite regularly divided into polygons, 5 mm. in diam., forming bases of irregular pointed or truncate pyramidal projections; outer cells of cortex mostly projecting and pointed, forming superficial layer of short, 1-celled hairs with somewhat thickened walls; cavity of asco-

carp irregular, due to infolding of wall but without projections; inner surface of wall verrucose, verrucosities narrower and lower than those of outer; primary cortex of large-celled pseudoparenchymatous tissue to depth of verrucosities, below which tissue abruptly changes to hyphal; asci cylindrical, constricted between spores, rounded at apex, 30 by 240μ; spores 1–seriate, ellipsoid, 24–28 by 32–34μ, surface covered with large, irregular, more or less densely crowded, flattened or conical papillae rarely reaching 4μ in height and 7μ in width (generally 2 by 4); spores 1–seriate, placed irregularly in ascus; paraphyses delicate, 3–8μ wide (generally 4μ) arising from hyphal tissue of primary cortex, and broadening above asci to form secondary cortex.

"Found in forest, Mt. Tamalpais, Marin Co., Calif., April."

No. 86, Harkness Collection, *type*.

While the spore surface of this species is similar to that illustrated by Tulasne (Fungi Hypogaei, tab. XIII) for *G. Klotzschii*, and answers to the description by Fischer of the type specimen of Berkeley and Broome (1897*b*, p. 24), the spore and ascus measurements are too small, those given for *G. Klotzschii* being for the former 31–45 by 21–32μ and for the latter, 270–320 by 35–42μ. Also, the color of the Californian species is lighter, it does not have the decided folds from the base to the apex described by Fischer as usually present, while the hyphal character of the primary cortex which is very marked in this species has been found in no description of *G. Klotzschii*. In the herbarium of the University of California is an Italian specimen from Mattirolo labeled *G. Klotzschii* which differs from our species in a very much more minutely verrucose surface, darker color of ascocarp, the presence of occasional strands of sterile tissue in primary cortex, larger and more nearly globular spores, and in the sculpturing of the spore surface, which in this case consists of very irregular papillae, the larger usually truncate and measuring sometimes 7 by 8μ. The specimen from Mattirolo represents the variation from the type plant cited by Fischer from Mattirolo's herbarium (1897*b*, p. 24), but the notes would indicate that the variation is only in the spore and the differences in ascocarp characters therefore would separate our plant as a distinct species.

The spore is very similar to Tulasne's illustration of the spore of *G. hispidula*, and the spore and ascus measurements agree with those cited for this species, but the lack of hispid character of the ascocarp, the lighter brown color, irregular cavity and presence of hyphal tissue (which is not described for *G. hispidula* and, from Tulasne's illustration, is evidently not present) would separate the two species.

One and a half specimens of this species are now present in the Harkness collection, and it is from these that the descriptions have been made.

Genea arenaria Hk.

Pl. 30, fig. 34

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 263.

Ascocarp brown, 1–2.5 cm. in diam., irregular, coarsely lobed and folded; surface divided into polygonal areas 5 mm. or less in diam., forming bases of low pyramidal projections rounded at apex; surface more or less covered with long, brown, septate hairs; cavity of ascocarp irregular through infolding of wall; inner surface of wall more closely verrucose than outer; outer half of primary cortex of large thin-walled cells, forming pseudoparenchymatous tissue; inner half composed of small, variously shaped cells elongated laterally and lying in more or less definite rows (parallel to surface) with walls coalescing; asci cylindrical, sometimes somewhat constricted between spores, rounded at apex, 20–28 by 200–240μ; spores 1-seriate, ellipsoid, 16–24 by 22–28μ, epispore thin, covered with minute irregular cylindrical, usually truncate verrucosities rarely reaching height of 4μ, generally 2μ or less; paraphyses slender, 4μ or less thick, branched below secondary cortex.

"In sandy ground. No locality or date." No. 42, Hk. Col. *Type.*
"In clay soil under oaks, Claremont Canyon, Berkeley, Calif., Mar. 4, 1903." No. 81, U. C. Col. N. L. Gardner.
"Under oak, Piedmont Park, Oakland, Calif., April 4, 1903." No. 96, U. C. Col. N. L. Gardner.
"In clay soil under *Quercus agrifolia,* U. C. Campus, Berkeley, Calif., Nov. 26, 1901." No. 225, U. C. Col. N. L. Gardner.
"Under *Quercus agrifolia.* U. C. Campus, Berkeley, Calif., Jan. 7, 1905." No. 247, U. C. Col. N. L. Gardner.
"Under *Quercus agrifolia,* U. C. Campus, Berkeley, Calif., Jan. 7, 1905." No. 248, U. C. Col. N. L. Gardner.

This species evidently comes near *Genea verrucosa* Vitt. and *Genea pulchra* Corda, but it differs from descriptions of these species in several points mentioned below. The spores of the material studied under all the numbers cited above are identical in being very minutely verrucose, with the projections mostly slender cylindrical and truncate, instead of either semi-globose or conical as described for *G. verrucosa* and figured by Tulasne (1851, pls. XII and XIII). The specimens differ from material from Mattirolo in the University of California collection bearing the name of *G. verrucosa,* in lighter color, the presence of hairs upon the ascocarp, verrucosities of the

spore more irregular and more slender, and narrower paraphyses (those of Mattirolo's specimen measuring 4–7μ in thickness). Descriptions of *G. pulchra* differ from this species in having the ascocarp even, without folds or inner projections, and in larger spores (21–25 by 28–31μ) covered with minute sharp-pointed needles.

While spore characters and all measurements are constant in different plants of this species, the characters of ascocarp surface and cortical tissue are quite variable. In No. 42, Hk. Col., Nos. 81 and 248, U. C. Col., very few hairs are found upon the surface of the ascocarp; while in other specimens they are comparatively plentiful. The structure of the cortex is also found to vary in different specimens. However, all of these variations are present to some extent in different plants of the same collection, and do not seem sufficient basis for specific separation, particularly since a single ascocarp occasionally exhibits striking variability in the characters mentioned above.

Genea Harknessii sp. nov,

Plate 29, figs. 10, 11, 12, 13

Genea hispidula Hk. non Berk., Proc. Cal. Acad Sci., 3d ser., vol. 1, no. 8 (1899), p. 263.

Genea verrucosa Hk. non Vitt., Proc. Cal. Acad Sci., p. 263.

Ascocarp dark brown to black, 2 cm. in diam., slightly flattened, somewhat lobed; surface divided into minute polygonal areas, forming bases of stout pyramidal projections; cavity of ascocarp much broken by irregular projections from wall; wall of cavity with verrucosities as wide as but lower than those of outer surface; primary cortex consisting of pseudoparenchymatous tissue of rapidly elongated, very large, dark, thick-walled cells extending to base of verrucosities; from here to asci, tissue becoming hyphal; hymenium often double from joining of inner projections of wall, divided into distinct "pockets" by strands of sterile hyphal tissue connecting cortices; asci cylindrical to somewhat club-shaped, not constricted between spores but covering spores loosely, stipitate, rounded at apex, 32 by 225μ; spores 1– or incompletely 2–seriate, 22–24 by 28μ, surface covered by semi-globose or truncate conical papillae, rarely reaching width and height of 4μ, usually variable in size, distribution, and shape on single spore; paraphyses 2–8μ in thickness, branched below secondary cortex.

"Strawberry Canyon, Berkeley, Calif., Mar. 27, 1915."
No. 429, U. C. Col. *Type*. N. L. Gardner.

"Among decaying leaves under trees, Santa Cruz, Santa Cruz Co., Calif., May." No. 70, Hk. Col. Referred to *G. verrucosa*.

"Beneath surface of ground under trees, San Rafael, Marin Co., Calif., May." "Under Oaks, Wire Bridge, Placer Co., Calif., April." No. 115, Hk. Col. Referred to *G. hispidula*.

No. 70 of this species is cited as *G. verrucosa* Vitt. by Harkness, while No. 115 is placed under *G. hispidula* Berk. The bottles in the Harkness collection bearing these numbers are both labeled *G. perlata*. The species differs from the description of *G. hispidula* (Fischer, 1897*b*, p. 20) in having smaller spores (the measurements cited for *G. hispidula* being 38–42 by 32μ) and in being glabrous. It also differs from descriptions of both *G. hispidula* and *G. verrucosa* (including *G. perlata* Corda) in having sometimes club-shaped asci, hyphal tissue in the primary cortex, branched paraphyses, and very conspicuously interrupted hymenium. In the University of California herbarium is an Italian specimen from Mattirolo which is labeled *G. verrucosa*, and which has somewhat larger spores than our plant, no apparent branching of the paraphyses, and no indication of interrupted hymenium. Bucholtz (1903) states that the hymenium of *G. verrucosa* is not continuous, but since this character is found mentioned in no descriptions it is apparently not conspicuous. The character of the hymenium of our species apparently excludes it from any described species, and seems sufficient basis, together with associated peculiarities of paraphyses and primary cortical tissue, for a distinct species.

Genea Gardnerii sp. nov.

Plate 28, figs. 7, 8

Genea sphaerica Hk. non Tul., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 263.

Ascocarp black, 1–1.5 cm. in diam., very much wrinkled and folded, surface minutely verrucose; cavity of ascocarp very irregular due to infolding of wall, but rarely to projections from wall; verrucosities of inner surface equal in size to those of outer; outer layer of both cortices pseudoparenchymatous, composed of coarse, dark, thick-walled cells, below verrucosities becoming small and thin-walled, colorless; cells of primary cortex gradually lengthening laterally, giving appearance of hyphae with united walls; hymenium conspicuously divided into "pockets" by sterile strands of tissue composed of united extensions from the two cortices, of pseudoparenchyma, or by such extensions joined by mass of paraphyses; asci cylindrical to more or less club-shaped, not constricted but loosely covering spores, rounded at apex, 34–42 by 280–425μ, tapering to stipe with latter sometimes much elongated; spores 1– or rarely incompletely 2–seriate, sometimes only 3 or 4 maturing in ascus, ellipsoid, 30–34 by 32–36μ; surface densely covered with broad (8μ) low, semi-globose papillae, these minutely and more or less evenly papillose; paraphyses irregular in shape with some cells long-cylindrical, others short and swollen; 3–9μ in width, branched.

"Under oak on top of ground beneath leaves, Piedmont Park, Oakland, Calif., Apr. 4, 1903." No. 97, U. C. Col. *Type.* N. L. Gardner. "Hypogaeous under *Quercus agrifolia.* Leona Heights, east of Oakland, Calif., Mar. 4, 1905." "Under *Quercus agrifolia.* Berkeley, Calif., Apr. 29, 1905." No. 249, U. C. Col. N. L. Gardner. "Beneath surface of ground under oaks, Contra Costa Co., Calif., May." No. 89, Hk. Coll. Referred to *G. sphaerica.*

Harkness quotes No. 89 under the name *Genea sphaerica* Tul. (Harkness, 1899, p. 263). The plants under this number in his collection, however, differ from the descriptions (Tulasne, 1851, p. 120, Fischer, 1897*a*, p. 24) of the above-named species in having much larger asci (those cited for *G. sphaerica* being 190–220 by 28–35μ); in the form of the ascocarp which in *G. sphaerica* is said to be more or less regularly globose with large anastomosing projections from the inner wall extending into the cavity; in the spores, those of the Californian plant being much more nearly globose than described for *G. sphaerica* and having much larger papillae bearing small secondary papillae which are not mentioned in descriptions of *G. sphaerica;* and finally in the interrupted hymenium, which character is so conspicuous in our species that it must certainly have been noticed and recorded if it were present in the European plants.

This species differs from *G. Harknessii* in the much more irregular ascocarp, absence of projections from inner wall, generally deeper color, lower verrucosities of surface, larger spores and asci, and in the shape and sculpturing of the spore, that of *G. Gardnerii* being nearly globose with more dense and much larger papillae. A hasty comparison of the ascocarps is insufficient, however, to distinguish between the two, for both are dark-colored and strongly verrucose, and may easily be mistaken for each other in the field. This evidently occurred in the case of the two citations given above under No. 249, for both species were found in the bottle bearing that number.

G. Gardnerii comes very near descriptions of *G. Klotzschii,* the spores of our species measuring a little smaller but of the same general type. However, while Bucholtz (1903, p. 162), in a comparison of the genera of the Tuberales, makes the statement that the hymenium of *G. Klotzschii* is not an uninterrupted layer, apparently this condition is not conspicuous, for I find no mention of it in any description of the species; neither do I find an account of branched paraphyses. In an Italian specimen from Mattirolo in the University of California herbarium, labeled *G. Klotzschii,* occasional strands of sterile tissue

are found in the hymenium but the latter is not divided into the distinct "pockets" characteristic of our species. No branching of paraphyses can be discovered in the Italian plant. The spores of the latter differ from those of ours in having much higher papillae which are truncate, conical or cylindrical, much less crowded, and the surface between them closely covered with very minute papillae. The latter are also distributed over the larger papillae as in ours, but not so conspicuously.

Fischer (1897*a*, p. 23) describes the spores of the type of *G. Klotzschii*, which, he states, approach those of *G. verrucosa;* and he compares with these the spores of material from Mattirolo, the description of which corresponds with the preceding description of a specimen from the same herbarium. Apparently the differences in the two examples occur, however, only in the spore, and as intermediate forms are found and wide variation can be seen in single specimens, he does not consider these a sufficient basis for a new species. In the Californian material, on the other hand, the variation from the type as described lies not so much in the spore as in the distinct character of the hymenium and in the form of the paraphyses, and it seems best at present to consider this a separate species.

The material in the University of California collection is in much better condition than the Harkness specimens. For this reason, descriptions and illustrations were made from No. 97 of the former, this being selected as the type of the species.

Genea intermedia nom. nov.

Plate 29, fig. 14

Hydnocystis compacta Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 262, pl. XLIII, figs. 11*a*–11*c*.

Ascocarp reddish brown, somewhat lobed, surface covered by rounded papillae varying in size, reaching 0.3 mm. in diam.; cavity of ascocarp apparently comparatively simple, inner wall following slight lobing of outer; outer wall more coarsely verrucose than inner; primary cortex only slightly thicker than secondary; both pseudoparenchymatous throughout, outer cells larger and somewhat thicker-walled than inner and all more or less compressed laterally; hymenium showing few "pockets;" asci cylindrical, sometimes constricted between spores, rounded at apex, 44 by 300μ; spores 1–seriate, globose, 36μ, smooth and hyaline when young, surface at maturity covered with semi-globose papillae varying in size on single spore from 5μ in height to very minute granules often coalescing in irregular groups; in dense

crowding of spores, papillae often rubbed off from surface; paraphyses 4μ in width, compressed in groups between crowded asci.

"Under *Libocedrus*, Alta, Placer Co., Calif., May."
No. 98, Hk. Col. *Type.*

Only two small portions of a plant, each about 7 mm. in diam., are now present in the Harkness collection, and therefore such points as size, shape, the presence or absence of an external opening and of projections from the inner wall, cannot be determined with certainty. In the material studied, however, the wall of the ascocarp is comparatively even, there being only slight lobing; no indications are found of inner projections; and an external opening was apparently originally present. The latter character may have been overlooked by Harkness as it apparently was overlooked in his genus *Myrmecocystis*. However, plants which in all other respects answer perfectly to the description of *Genea* but which lack an opening are found in the University of California collection; and even the absence of this character, therefore, would not seem sufficient alone to debar the species from this genus. Its transference to *Genea* from *Hydnocystis*, where it was placed by Harkness, is justified by the presence of a secondary cortex formed by the paraphyses. Because of its spore shape and size and the densely crowded arrangement of the asci and paraphyses, however, it cannot be separated from *Myrmecocystis* upon the old basis of distinction between the latter and *Genea*, and must therefore be considered under *Genea* in the enlarged sense.

Since the specific name *compacta* has already been used by Harkness in connection with *Genea*, the name *intermedia* is proposed.

Genea cerebriformis (Hk.) comb. nov.

Myrmecocystis cerebriformis Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 269, pl. XLV, figs. 28*a*–28*c*; Bot. Zeit., 1908, p. 145, pl. VI, figs. 1–3, Ed. Fischer.

Myrmecocystis candidum Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 269, pl. XLV, figs. 29*a*–29*e*.

Pseudogenea californica Fischer, Ber. deutsch. Bot. Ges., 1907, p. 372.

Ascocarp creamy white, 1 cm. in diam., very irregular in form with conspicuous convolutions, these in turn being minutely convoluted; surface covered by minute mostly conical verrucosities; cavity of ascocarp dissected by infolding of and projections from wall into system of labyrinthine canals; inner wall more minutely verrucose than outer; cortices composed of large-celled pseudoparenchyma to somewhat be-

low base of verrucosities, cells in more or less distinct radial rows and elongating toward center of ascocarp, this tissue becoming smaller-celled and, in primary cortex, changing to more or less connected hyphal tissue to bases of asci; hymenium sometimes double, partitioned into irregular, mostly bent "pockets" by strands of cortical tissue; asci crowded, separated by fascicled paraphyses; asci more or less deformed by pressure, cylindrical to somewhat club-shaped, normally 8-spored but some spores often not maturing, not constricted between spores, rounded at apex, 40 by 180–250μ; spores 1– or incompletely 2–seriate, globose, 28–40μ, smooth and hyaline when young, at maturity smoky yellow, densely covered by long, slender spines with enlarged bases, bases often coalescing in groups and making surface of spore appear irregularly rugose; paraphyses 4–6μ in width, difficult to distinguish separately because of dense crowding between asci.

"In sandy places under oaks, Wire Bridge, Placer Co., Calif., May."
No. 25, Hk. Col. *Type.*

"In rich sandy soil under oaks, Alameda Co., Calif., June."
No. 18, Hk. Col. *Type* of *M. candidum.*

"About 3 inches deep in soil under oak, Piedmont Park, Oakland, Calif., Apr. 4, 1903." No. 98, U. C. Col. N. L. Gardner.

"Hypogaeous under *Salix,* Sunset Park, Santa Clara Valley, Calif., May 17, 1903." No. 145, U. C. Col. N. L. Gardner.

"In gravel soil under *Quercus agrifolia,* Leona Heights, east of Oakland, Calif." "Under *Arbutus Menziesii,* Mar. 8, 1905." "Under *Quercus agrifolia,* hills by Lake Temescal, Oakland, Calif., Aug. 11, 1905."
No. 272, U. C. Col. *Type* of *Pseudogenea californica* Fischer. N. L. Gardner.

"Under *Quercus agrifolia,* Dimond Canyon, East Oakland, Calif., Mar. 14, 1914." No. 401, U. C. Col. N. L. Gardner.

The plants found under No. 18 and labeled *Myrmecocystis candidum* are apparently young specimens of No. 25, Hk. Col. The spores, which are immature, are similar to undeveloped spores found in No. 25, and the form and structure of the ascocarps of the two are identical. The spores of this species are very peculiar in their sculpturing. The spines appear to be covered by a transparent membrane which holds them rigid, but where this has broken away leaving the ends free, they are seen to be long and flexible, tapering gradually from an enlarged base. The coalescing of these bases in groups of irregular lines gives the sculpturing a netted appearance, but the extent of such coalescence varies greatly in different spores of a single plant, and often every gradation is found between spores whose spines are entirely separate and those whose surfaces are completely covered by a network of connected bases. The ends of the spines are not united in

any case. A similar coalescence of projections of spore surface is found in *G. intermedia* to a much less marked degree.

The form of the hymenium in this species seems to be a further development of that of the species under *Heterogenea* in which are likewise found, though less conspicuously, fascicled paraphyses and strands of cortical tissue between groups of asci. In *Genea cerebriformis* the "pockets" of the hymenium are described by Fischer as more or less strongly bent (1908, p. 145). This is due to the minute lobing, previously described, of the ascocarp, the hymenium naturally lying parallel with the surface. The partitions occur usually at the bases of the small convolutions; but there seems to be no definite relation of this kind, for in cases of larger convolutions, partitions are found distributed promiscuously through the arch.

Fischer states that the central hollow of the ascocarp opens to the surface at various points at the bases of folds (1908, p. 145). It is true that openings usually exist beneath several folds of a single ascocarp, but so far as I have observed they are all connected, the original single simple mouth described for *Genea* having here become exceedingly irregular by the very decided lobing of the ascocarp.

Hydnotrya Berk. et Broome emend.

Ascocarp subglobose, surface generally folded or with projections into exterior; gleba penetrated by hollow chambers or labyrinthine canals opening to surface usually between folds or into inward extending projections of surface; canals lined with hymenium; asci forming palisade with paraphyses or more or less irregularly imbedded in tissue below; asci cylindrical, club-shaped, or long-ovoid, 6–8-spored; spores globose or ellipsoid, minutely or very coarsely papillose; paraphyses more or less swollen at tips, at external openings of chambers continuing into surface of ascocarp as swollen-tipped hyphae.

No typical species of *Hydnotrya* have thus far been reported from California; but the two anomalous species referred to this genus differ as widely from each other as from the type, and consequently can be disposed of only by establishing two new genera or by enlarging the original genus. The latter method is chosen at present; first, because only one preserved specimen of each exists, so far as I have been able to discover; and, second, the dissimilar characters of the two in relation to the type species of the genus seem less important than the characters which are similar. Further collection and study of these plants, however, may make another arrangement necessary.

Ascocarp of loose folds, forming large chambers; paraphyses scarcely swollen; spores ellipsoid, minutely papillose. *H. ellipsospora.*

Ascocarp containing narrow labyrinthine canals; paraphyses conspicuously swollen; spores globose, minutely papillose. *H. cerebriformis.*

Hydnotrya ellipsospora sp. nov.

Plate 30, fig. 38

Ascocarp purplish brown, 1.5 cm. in diam., subglobose, composed of loose folds occasionally joined; surface of ascocarp minutely villose; interior of large, hollow, connected chambers opening without at various points; wall of ascocarp 1 mm. thick, lined with hymenium, the transition of hymenium to cortex at external openings plainly visible; hyphae of wall somewhat connected immediately below external surface; hyphae at surface distinctly separated, somewhat swollen at tips, 9–18μ thick, continuing into hymenium as slender paraphyses; asci cylindrical, not constricted between spores, 10 by 260μ, 8-spored; spores 1-seriate, ellipsoid, 10 by 14μ, minutely papillose; paraphyses not produced beyond asci, little swollen, 2–5μ thick.

"Under *Quercus agrifolia*, Pacific Grove, Calif., Dec. 1909."
No. 316, U. C. Col. *Type.* N. L. Gardner and M. B. Nichols.

This species differs from the descriptions of the genus *Hydnotrya* in having mostly large, open, connected chambers, regularly cylindrical, closely crowded asci, and ellipsoid, minutely papillose spores; rather than labyrinthine canals, mostly club-shaped or long-ovoid, 6–8-spored asci, and globose spores with very thick, coarsely papillose epispore, described for *Hydnotrya.* The spores are much smaller, also, than reported for any described species of which I have found record, those of *H. Tulasnei*, for instance, cited as 25–35μ and those of *H. jurana,* 30–40μ. However, the ascocarp is of the general structure of *Hydnotrya,* i.e., irregularly folded, forming empty cavities between, which open to the surface; the surface is covered with crowded separate hyphae, more or less swollen, which continue into the hymenium as paraphyses; and the structure between the hymenium and the outer surface of the wall is hyphal. It has seemed best at present, therefore, to extend the genus *Hydnotrya,* rather than to establish a new genus for this species.

Hydnotrya cerebriformis Hk.

Plate 30, fig. 27

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 266, pl. XLIV, figs. 19*a*–19*f*.

Ascocarp "salmon," 2.5 cm. in diam., subglobose, coarsely lobed, with several deep, close folds; surface minutely villose; gleba white or yellowish, penetrated by long, labyrinthine, connected, narrow canals, the walls lined with hymenium; canals hollow but often so narrow that tips of opposite rows of paraphyses are in contact; outer cortical tissue of tangled hyphae 10μ in thickness, with 3 or 4 terminal cells of each projecting, swollen, reaching thickness of 20μ; upon infolded surface these swollen hyphae larger, sometimes 36μ thick: hyphae toward hymenium becoming more compact but conspicuously tangled and interwoven; hymenial tissue similar, bearing palisade-like asci and paraphyses, latter a continuation of swollen hyphae of ascocarp surface; asci cylindrical, 8-spored, not constricted between spores, rounded or slightly pointed at tips, 28 by 220μ; spores brown, globose, 25–32μ, minutely papillose; paraphyses with terminal cell swollen, 12–16μ thick, swollen tips projecting beyond asci in fan-shaped clusters.

"Among fir trees, Donner Lake, Nevada Co., Calif., July."
No. 37, Hk. Col. *Type.*

While this species has very regularly cylindrical asci, conspicuously swollen hyphae, and minutely papillose spores, all more or less contrary to former descriptions of these parts in the genus *Hydnotrya*, yet its general structure and its other characters come so near that it seems best to refer it to this genus. With the addition of conspicuously swollen paraphyses to the generic characters, this species can be referred without difficulty to *Hydnotrya* as it is enlarged to include *H. ellipsospora*.

Only one specimen is found in the Harkness collection, and this has been cut in two. The preceding description, with the exception of color, has been made from the single plant. The color is quoted from Harkness. A discrepancy is noted between his description of the spore surface and that given above. This point is very difficult to determine, for the sculpturing is exceedingly minute; and very small regular foveolate or alveolate markings and closely and regularly placed papillae appear very similar under the microscope. However, from a study of the margin of sectioned spores, and of surfaces which have been separated from the body of the spore, it seems clear that the epispore is papillose rather than foveolate.

Tuber Mich.

Ascocarp regularly globose to very irregular, fleshy or cartilaginous; surface smooth, verrucose, or with coarse projections; cortical tissue often pseudoparenchymatous; subcortex of laterally extending hyphae, loosely arranged or more or less united; gleba penetrated by venae externae and venae internae (latter rarely wanting); venae externae filled with hyphae, opening at various points of surface, or converging more or less distinctly at one point or line or several points or lines; venae internae originating from subcortex, lying usually parallel with venae externae, composed of generally parallel hyphae, loosely arranged or more or less united, sometimes pseudoparenchymatous; hymenium lying between two vein systems, consisting of irregularly arranged asci separated by strands of tissue generally similar in structure to that of venae internae; asci usually numerous, pyriform, ellipsoid or nearly globose, with 1 to 4 or more spores, number varying in asci of single ascocarp, size of spore varying with number in ascus; spores ellipsoid or globose, alveolate or spiny, irregularly arranged in ascus.

The genus *Tuber* is generally divided into two subgenera: *Eutuber*, with the venae externae opening at various points of the surface, and the consistency of the ascocarp generally fleshy; and *Aschion*, with the venae externae converging and opening at the base of the ascocarp, the consistency of the latter being hard, horny, or woody. No plants of the true *Aschion* type have yet been reported from California, but it is approached by *Tuber candidum* and *T. lignarium*, both having a somewhat cartilaginous ascocarp with venae externae converging and opening to the surface along a definite line or point or several connected or separated lines or points. These lines are somewhat irregularly arranged, sometimes occurring singly on one side of the ascocarp, but often extending half the distance around it, and more or less branched, or joined by other lines.

Sometimes there are a number of short lines, or occasionally several of these are reduced to points, and in these cases there are as many "centers" of converging venae externae. There is no definite orientation of the plant in relation to these lines, for they may be found upon the upper surface or a side of the ascocarp as often as at the base.

According to the sculpturing and shape of the spores, *Tuber* species have been divided into four groups: *Eutuber*, including those with ellipsoid, alveolate spores; *Sphaerotuber*, with globose, alveolate spores; *Oögaster*, with ellipsoid, spinose spores; and *Sphaerogaster*, with globose, spinose spores. By far the greater number of Cali-

fornian species that have been collected have alveolate spores; and of these species all but one must be included under *Eutuber*. No specimens of true *Sphaerogaster* have yet been reported, though *T. lignarium* comes very near. The same relationship evidently exists in Europe between globose and ellipsoid-spored species, the latter being far in the majority.

In the descriptions which follow, aside from the size, shape and surface characters of the ascocarp and spore, there have been considered the thickness of the peridium and the structure of the venae internae and the tissue lying between the asci. The two latter tissues originate from the subcortex and are generally similar in character; but occasional cases are found in which one has become modified without a corresponding modification of the others. The structure and arrangement of these three tissues are not always constant in a species, but generally they are little variable. In a number of cases these tissues are composed of long-celled hyphae, more or less regularly arranged, which have coalesced, forming practically a pseudoparenchymatous layer of somewhat elongated cells of various sizes. Sometimes, also, apparently true pseudoparenchyma exists in such tissues, the latter appearing in section as an even layer of equal, united, globular cells. Whether this is really pseudoparenchyma, or whether the effect is produced by a section across the long diameters of the united hyphae previously described has not yet been determined. An illustration of these two tissues will be found in the figure of *T. candidum*, plate 27.

EUTUBER. Spores alveolate, ellipsoid.

A. Surface of ascocarp smooth.

a. Ascocarp lobed or convolute.

Ascocarp reaching 2 cm. in diam., yellow; asci 1–4-spored; spores 26–36 by 30–44μ; 7 by 8 alveoli across diameters ..... *T. citrinum.*

Ascocarp reaching 1.5 cm., dirty white, lobed and wrinkled; asci 2–4-spored; spores round-ellipsoid, 28–34 by 32–40μ; 11–14 by 12–16 alveoli across diameters ..... *T. monticolum.*

b. Ascocarp even.

Ascocarp reaching 2 cm., clay-brown; asci 1–4-spored; spores round-ellipsoid, 32–48 by 36–52μ; 3–10 by 4–13 alveoli across diameters.. ..... *T. levissimum.*

B. Surface of ascocarp verrucose, scabrous, or minutely wrinkled.

a. Ascocarp lobed or convolute.

Ascocarp reaching 1.5 cm., cinnamon-brown, minutely scabrous; spores long-ellipsoid, pointed at both ends, 28–38 by 36–52μ; 6 by 7 alveoli across diameters ..... *T. gibbosum.*

Ascocarp reaching 1.2 cm., lead-purple, minutely verrucose; asci 1–3-, rarely 4-spored; spores round-ellipsoid, 40–48 by 48–56μ; 5–10 by 7–11 alveoli across diameters ..... *T. separans.*

Ascocarp reaching 1 cm., depressed globose, minutely verrucose with occasional more coarsely verrucose areas; asci 1–3- (generally 1–2-) spored; spores 36–48 by 40–56μ; 3–8 by 3–9 alveoli across diameters ..... *T. irradians.*

Ascocarp reaching 1.5 cm., brown, finely convolnted, verrucose; asci 1–5- spored; spores 24–30 by 28–48μ; 3–11 by 5–14 alveoli across diameters ..... *T. Gardnerii.*

Ascocarp 0.3 to 2.5 cm., silver white with occasional smooth areas of darker color; depressed, irregular, convolute and often finely wrinkled, more or less divided into minute areas by crossing of wrinkles, sometimes having short, blunt hairs; asci 1–4- (generally 1–2-) spored; spores 28–44 by 38–56μ; 8–9 by 9–10 alveoli across diameters ..... *T. argenteum.*

b. Ascocarp even.

Spores greenish yellow, 7–11 by 8–12 alveoli across diameters.. *T. australe.*

Sphaerotuber. Spores alveolate, globose.

Ascocarp very uneven, pubescent; spores dark brown, 40–48μ in diameter..... ..... *T. californicum.*

Oogaster. Spores spinose, ellipsoid or ovoid.

Ascocarp minutely verrucose, at least about furrows; spores ovoid to long ovoid, 22–32 by 28–40μ, with straight spines..... *T. candidum.*

Ascocarp entirely smooth; spores globose-ellipsoid to globose, 20–32μ, with spines having recurved tips ..... *T. lignarium.*

Eutuber

Tuber (Eutuber) citrinum Hk.

Plate 29, fig. 18

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 271, pl. XLV, figs. 30*a*–30*c*.

Ascocarp pale yellow, 2 cm. in diam., somewhat convolute, surface entirely smooth, gleba somewhat lighter yellow than cortex; veins inconspicuous; cortical tissue pseudoparenchymatous: cells nearly equal in size, outer walls not thickened; cells becoming gradually lengthened laterally and changing to laterally extending, more or less connected hyphae of subcortex; thickness of peridium, 520–540μ; venae internae and tissue between asci consisting of long-celled, loose, irregular, unconnected hyphae, scarcely branched, 5μ thick; venae externae filled with coarse, much-branched hyphae, 4–6μ thick, so regularly branched and openly arranged as to appear reticulate; asci somewhat long-stipitate, semi-globose, 64–78 by 72–96μ, 1–4-spored; spores ellipsoid, 26–36 by 30–44μ, alveolate, 7 by 8 alveoli across diameters.

"In forest, Tamalpais, Marin Co., Calif., May."

No. 123, Hk. Col. *Type.*

In general characters as shape of ascocarp, smooth surface and absence of pronounced base, this species seems to come near *Tuber foetidum* Vitt. and *T. australe* Speg. The former as described, however, differs in the reddish-brown gleba, longer spores in comparison to their width, larger and fewer alveoli, and probably in the very disagreeable odor. It is impossible to determine from alcoholic material the presence or absence of the latter character, but if it were as decided in the Harkness material as it is said to be in the European specimens of *T. foetidum*, it would doubtless have been mentioned by Harkness. *T. australe* is described as "dirty-white, gleba white becoming gray, asci at first 2–3- then 1–2-spored, spores 35–38 by 45–50μ" (Paoletti, 1889, p. 888), in all of these characters disagreeing with our species. Its color and thickness of peridium, as well as the distinct vein and spore characters, seem sufficiently important to keep it as a distinct species.

Tuber (Eutuber) monticolum Hk.

Plate 30, fig. 23

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 271.

Ascocarp dirty white, 1.5 cm. in diam., lobed and wrinkled, surface very minutely scabrous; gleba white, netted with many small veins; outer cortical tissue pseudoparenchymatous, cells varying little in size, walls not thickened, outer layer breaking away slightly in places, making surface of ascocarp minutely scabrous; pseudoparenchyma changing gradually to very loose, branched, irregular hyphae, bordered below by close, more or less connected hyphae, becoming pseudoparenchymatous in places; venae internae of similar structure to latter tissue; thickness of peridium variable, 280–640μ; asci semiglobose, 64–80μ, 2–4-spored; spores globose-ellipsoid, very minutely alveolate, 11–14 by 12–16 alveoli across diameters; spores 28–34 by 32–40μ.

"Among firs in dense woods in Sierra Nevada Mts., at Towle, Placer Co., Calif., July." No. 27, Hk. Col. *Type.*

In cross-section this species appears somewhat like *Tuber levissimum*, for the pseudoparenchymatous tissue of the cortex is very narrow, and the peridium (in places) is unusually thick; but the whole structure is more delicate, the subcortical tissue is more irregular and unconnected, the spores are much more minutely alveolate, and the general appearance of the ascocarp—as observed from the two descriptions—is very different.

Tuber (Eutuber) levissimum sp. nov.

Plate 30, fig. 31

Tuber Borchii Hk. non Vitt., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 272.

Ascocarp clay-brown, 2 cm. in diam., regular; surface smooth: gleba lighter brown than cortex; veins large, inconspicuous in color; cortical tissue barely pseudoparenchymatous, composed mostly of more or less closely coalesced irregular hyphae, becoming less connected toward hymenium; outer cells slightly broken away, making surface of ascocarp very minutely scabrous, this character visible only under compound microscope; thickness of peridium 840μ; venae internae and tissue between asci of compact, more or less closely coalesced parallel hyphae, 5–6μ thick; venae externae filled with similar hyphae loosely arranged, not parallel, unconnected; asci subglobose to globose, 50–80 by 70–100μ; 1–4-spored; spores globose-ellipsoid, 32–48 by 36–52μ, alveolate, alveoli irregular in size and number on spore, 3–10 by 4–13 across diameters; sculpturing 4μ thick.

"In rich, damp loam, about 9 in. below surface, May, 1912."
No. 338, U. C. Col. *Type.* C. F. Drew.
"Among decaying leaves of oak, Mt. Tamalpais, Marin Co., Calif., June." No. 54, Hk. Col.

This species agrees very closely in shape and color of ascocarp; venation; and shape, size and sculpturing of the spores, with the descriptions of *Tuber Borchii* Vitt. The alveoli of the spores of the latter, however, are described as generally very regular in form. In the Californian material this is found to be the case in perhaps one-half of the spores of a plant. In the others irregularity in size and shape exist to a noticeable degree. No evidence of pubescence or spots of dark color on the surface of the ascocarp is found, but as these are both described as early characters in *T. Borchii* which disappear with maturity their absence is not necessarily important. No mention is made in descriptions of *T. Borchii* of the very thick peridium nor of the small amount of pseudoparenchyma in the cortex; and the description of the subcortical layer as composed of irregular, loose, interwoven hyphae does not agree with that layer in the Californian plants, in which it is a regularly arranged, generally compact tissue of more or less coalescing hyphae.

Of the Harkness material only three portions of specimens are now present in the collection, making impossible the determination of points such as size. The material in the University of California herbarium, being more ample in quantity and in much better condition, has been selected as the type.

Tuber (Eutuber) gibbosum Hk.

Plate 29, fig. 15

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 273.

Ascocarp "cinnamon-brown," 1.5 cm. in diam., convolute, surface minutely scabrous, gleba ochraceous; veins barely distinguishable; outer cortical cells forming branched, knotted hairs parallel with surface; inner cortical tissue pseudoparenchymatous, deeply colored, changing to colorless laterally extending hyphae of subcortex; thickness of peridium 200μ; venae internae of long, compactly arranged but unconnected hyphae; venae externae of loose, spongy tissue composed of branched, irregular hyphae, 4–5μ thick; venae externae opening in depressions of surface, depressions filled with parallel, irregular, colored hairs of surface of ascocarp; spores dark brown, long-ellipsoid, pointed at ends, 28–38 by 36–52μ (mostly 32 by 44μ) alveolate, mostly 6 by 7 alveoli across diameters, sculpturing 4μ thick.

"Under oaks, Mill Valley, Marin Co., Calif., April."
No. 162 Hk. Col. *Type.*

Of this species only one specimen is found in the Harkness collection, and from this a small section has been removed. The plant is infested with what appears to be an ascomycetous parasite which has nearly destroyed the tissue of the gleba, making a study of this structure difficult. However, occasional unaffected portions are to be found, and is possible from the material to describe all parts of the ascocarp except the asci, which have almost entirely disappeared, only occasional pieces of membrane remaining. The size and shape of the asci, therefore, and the number of spores they contain cannot be determined with accuracy. Through the venae internae, which in most cases are found to have more or less completely disintegrated, run long, coarse, branched hyphae, which apparently belong to the parasite.

This species seems to come nearest *T. oligosporum* as it is described by Vittadini who established it. Like the Harkness specimen, *T. oligosporum* is said to be lobed, with venae externae opening in depressions filled with hyphae. The surface is illustrated as conspicuously verrucose, however, the color of the ascocarp is described as reddish black, that of the gleba and spores as sooty white, and the spore shape is simply stated as oval. There are no measurements. A distinguishing point used by Vittadini is the odor, which cannot be determined in the alcoholic material. The character of the surface and the colors cited do not agree with those of the Harkness material, as will be seen

in a comparison of the two preceding descriptions, while the principal distinguishing characteristics of the spore of the latter plant, *i.e.*, long-ellipsoid with decidedly pointed ends, is not mentioned in Vittadini's description. Except for three views of the ascocarp in Vittadini's *Monographia Tuberaceorum*, I have been unable to find illustrations of *T. oligosporum*. It is apparently rare, for Tulasne simply paraphrases the original description, noting at the end "non vidimus," while Fischer, in Rabenhorst's *Kryptogamen-Flora*, includes it under the heading "Ungenügend bekannte Arten."

While the differences in color and surface characters may not be sufficient to separate our specimen from *T. oligosporum*, yet so many points are at present doubtful that it seems best to keep them distinct until more data for both can be secured.

Tuber (Eutuber) separans sp. nov.

Plate 29, fig. 19

Tuber excavatum Hk. non Vitt., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 273.

Ascocarp lead-purple (preserved) 1 to 1.2 cm. in diam., semi-globose, convolute, surface very minutely verrucose; gleba similar in color to cortex; veins inconspicuous; cortex pseudoparenchymatous, cells becoming smaller within and changing to compact subcortical layer of unconnected hyphae; walls of outer cortical cells somewhat thickened; thickness of peridium 200–260μ; tissue between asci of mostly loose, unconnected not parallel hyphae, 4–6μ thick; venae internae very compact, hyphae parallel, often connected, sometimes becoming pseudoparenchymatous; venae externae filled with loose, tangled hyphae 4–6μ thick; asci short stipitate, semi-globose, 56–68 by 60–92μ, 1–3-, rarely 4-spored; spores brown, globose, ellipsoid, 40–48 by 48–56μ, alveolate, 5–10 by 7–11 alveoli across diameters.

"Beneath oaks in clayey soil, Laundry Farm, Alameda Co., Calif., April." No. 159, Hk. Col. *Type*.

The single specimen found under No. 159, which is listed by Harkness as *Tuber excavatum*, shows no indication whatever of the basal cavity which is described as characteristic of that species. The alveoli of the spore are smaller and more irregular in number and size than they are described for *T. excavatum*, and the venae internae are not composed of tangled hyphae. Instead of converging at the base as in the latter species, the venae externae open at various points of the surface. The species comes nearest *T. irradians* and *T. Gardneri* but

it differs from the former in its smaller, thicker-celled pseudoparenchymatous cortex, with the cells not in radial rows, more compact subcortical tissue, more compact venae internae sometimes becoming pseudoparenchymatous, asci never long-stipitate and alveoli generally smaller; while it is distinguished from *T. Gardnerii* by its exceedingly minutely verrucose surface, more compact subcortical layer and venae internae, asci 1–3-spored, spores shorter in comparison to width, and sculpturing less variable. The structure of the venae internae is particularly characteristic. It was difficult to secure complete sections of the material, for the hymenium fell away under the knife; but the dense tissue of the venae internae remained, in most cases, for long distances, forming the skeleton of the original gleba. In no other case was this marked difference in delicacy between the various tissues observed.

Tuber (Eutuber) irradians sp. nov.

Plate 29, figs. 16, 17

Ascocarp brown, 1 cm. in diam., depressed globose, somewhat lobed; surface minutely verrucose with occasional areas more coarsely verrucose; gleba at first white, becoming brown; veins few, little branched, white; cortical tissue pseudoparenchymatous, cells thin-walled, large (to 24μ), in more or less clearly distinct radial rows to depth of 140–160μ, changing abruptly to loose hyphal structure of subcortex; thickness of peridium 380μ; venae internae and tissue between asci of somewhat loosely arranged unconnected hyphae, 5μ and fewer thick; venae externae filled with loosely interwoven hyphae 5μ thick; asci sometimes long-stipitate, easily separable from hyphae, pyriform, elongated or subglobose, 44–64 by 76–92μ, 1–3-spored (generally 1 or 2); spores brown, ellipsoid, 36–48 by 40–56μ, alveolate, number of alveoli variable, 3 by 3 to 8 by 9 (usually 7 by 8) across diameters; sculpturing 4–6μ thick.

"Hypogaeous under *Quercus agrifolia*, Dimond Canyon, Alameda Co., Cal., Mar. 25, 1905." No. 281, U. C. Col. *Type*. N. L. Gardner.

The regular arrangement in radial rows of the pseudoparenchymatous cortical cells, in this species, together with the marked variability in number and size of alveoli upon the spore, distinguish it from related forms as they have been described. The possession of a pseudoparenchymatous cortex and of a verrucose surface separate it from descriptions of *T. maculatum* and *T. dryophilum*. It is probably most closely related to *T. Gardnerii* but differs in several points which are mentioned under that species.

Tuber (Eutuber) Gardnerii sp. nov.

Plate 30, fig. 30

Ascocarp brown, 1.5 cm. in diam., subglobose, with small convolutions; surface verrucose; gleba white in young specimens, light brown in mature plants; veins wide, conspicuous, white; outer cortical tissue somewhat coarsely pseudoparenchymatous, thin-walled, changing gradually to subcortical layer of unconnected hyphae; thickness from surface to hymenium 240–320μ; venae internae and hymenial tissue of mostly slender, unconnected hyphae, 2–4μ thick; venae externae of loosely arranged branching hyphae 2–4μ thick; asci not stipitate, semiglobose, rarely elongated, 56–68 by 80–88μ; 1–5-spored; spores light brown, globose-, or long-ellipsoid, 24–30 by 28–48μ, alveolate, number of alveoli varying from 3–11 by 5–14 across diameters; sculpturing 2–4μ in height.

"Hypogaeous under *Arbutus Menziesii*, Leona Heights, Alameda Co., Calif., Mar. 4, 1905." "Under *Quercus agrifolia*, U. C. Campus, Berkeley, Calif., Mar. 22, 1905." "Under *Quercus agrifolia*, U. C. Campus, Berkeley, Calif., Apr. 29, 1905."
No. 274, U. C. Col. *Type*. N. L. Gardner.

This species apparently resembles most closely *Tuber foetidum*, *T. dryophilum*, and *T. maculatum*. However, nothing is recorded in regard to its odor; and its most noticeable characteristic, i.e., the exceeding variation in number and size of alveoli upon a spore, is not mentioned in descriptions of *T. foetidum*, while Tulasne's figures (1851, pl. XVII, fig. VII) would indicate that they are uniform, at least in size. In *T. foetidum* the asci are described as ellipsoid and 1–2-, rarely 4-spored, these characters both differing from those of our specimens. The species differs from the original descriptions of *T. maculatum* and *T. dryophilum* and as they are described by Fischer (1897*b*, pp. 47 and 51 respectively) in its verrucose, unspotted surface, possession of pseudoparenchymatous cortex, smaller spores, and narrower alveoli, those of *T. maculatum* given as 7–10μ, and of *T. dryophilum*, 14 by 21μ, though the latter is said by Fischer (*ibid.*, p. 52) to have sometimes more finely alveolate spores occurring with the more common widely alveolate ones. In the Californian material, the variation in alveoli is very remarkable, occurring not only in a single plant, but even in a single ascus. It is often the case, probably usually, that two or three spores in an ascus differ widely in the size and number of alveoli. In one ascus, for example, three spores were present, the first measuring 28 by 32μ and having 3 by 4 alveoli across the diameters, averaging 8μ in width; the second was 24 by 28μ, having 7 by 9 alveoli,

averaging 3μ; and the third was 32 by 40μ, with 7 by 8 alveoli, averaging 5μ. Among the smaller spores, the number and size of alveoli do not appear to be directly related to spore size; but the largest spores, i.e., those occurring singly in an ascus, usually have the greatest number and the smallest alveoli.

This species differs from *T. irradians* (which shows the similar irregularity in spore sculpturing) in color, being darker; in the ascocarp, which is larger, much more uneven, and more conspicuously verrucose; in outer cortical cells which, while coarse, are not in rows, and merge more gradually into subcortical tissue; in spores, which are not so dark brown and are smaller.

Tuber (Eutuber) argenteum sp. nov.

Plate 30, fig. 28

Ascocarp silver-white with occasional smooth areas of darker color, horny; 3 mm.–2.5 cm. in diam., depressed, irregular, convolute and sometimes minutely wrinkled; surface smooth or in places divided into minute areas by crossing of wrinkles, more or less covered by slender, short, blunt, septate hairs; gleba brownish with white branching veins; cortical tissue pseudoparenchymatous or coarsely and loosely hyphal, outer cells often forming hairs; subcortical layer of very loose, irregularly placed hyphae; thickness of peridium 100–200μ; venae internae numerous, of loose, irregular structure similar to subcortex and tissue between asci, hyphae 5–7μ thick; venae externae fewer, filled with loose, irregularly interwoven, branched hyphae 5–7μ thick; both venae internae and venae externae much enlarged at junction with peripheral layer of ascocarp; asci with or without short stipe, semi-globose, 64–78 by 76–92μ, 1–4-spored (generally 1 to 2); spores dark brown, ellipsoid, sometimes one end acute, 28–44 by 38–56μ, regularly and mostly evenly alveolate, generally 8–9 by 9–10 alveoli across diameters, sculpturing 4μ thick.

"In sand among needles of *Pinus attenuata*, Ingleside, San Francisco Co., Calif., May 11, 1905."

No. 284, U. C. Col. *Type*, N. L. Gardner.

The generally smooth, somewhat spotted surface of the ascocarp of this species, together with the spore shape and size, seem to place it near *Tuber maculatum* Vitt. and *T. dryophilum* Tul. However, it differs from descriptions of both in having a pseudoparenchymatous cortex, and in color, that of *T. maculatum* described as first white, becoming spotted with yellow, finally entirely golden yellow, and that of *T. dryophilum* as brownish with reddish violet spots. The alveoli

of the spore surface of *T. dryophilum* are said to measure 14 by 21μ, while those of *T. argentcum* are generally 6–8μ. The former is also recorded as having occasional more minutely alveolate spores occurring with those of coarser alveoli, but in the Californian species the number and size of alveoli vary little.

Tuber (Eutuber) australe Speg. (?)

Plate 30, fig. 29

Spegazzini, Ann. de Soc. Cien. Argentina, vol. 24 (1887), p. 122.
Harkness, Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 272.

Ascocarp reddish brown (preserved), 1 cm. in diam., nearly globose, very even with few wrinkles, minutely verrucose; gleba yellow gray, of loose texture; veins not conspicuous in cut surface; pseudoparenchymatous layer of cortex thin, changing soon to compact tissue of coalescent hyphae of subcortex; thickness of peridium 480μ; venae internae and tissue separating asci of similar structure to subcortex, with hyphae somewhat less closely united; venae externae of loosely interwoven branched hyphae 5–6μ thick; asci more or less pyriform, 48–60 by 60–80μ, 1–2-spored; spores greenish yellow, nearly globose, 30–40 by 32–48μ, alveolate 7–11 by 8–12 alveoli across diameters.

"Among oaks in vegetable humus upon a well-drained hillside, Auburn, Placer Co., Calif., June." No. 203, Hk. Col.

It is difficult to decide whether or not this species is identical with *Tuber australe*, for descriptions of the latter species are meagre, and no illustration of it exists, so far as I have been able to determine. Also, only one specimen of the Harkness material is present in the collection, and Harkness made no critical notes upon this species. Which characters are variable in different plants, therefore, and which are modified by the preserving alcohol must remain in doubt. However, most characters of the alcoholic specimen agree in general with the descriptions of *T. australe*, the color of the ascocarp being the only serious point of disagreement. This, however, has probably changed since the specimen was preserved. The surface of the Harkness plant is also slightly verrucose rather than smooth as described for *T. australe*, but this amount of variation sometimes occurs in different plants of a species. It seems best, therefore, to leave this specimen under *T. australe* until more material may be available for study.

Tuber (Sphaerotuber) californicum Hk.

Plate 29, fig. 20

Tuber Magnatum Hk. non. Pico. Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 272.

Tuber puberulum Hk. non B. et Br., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 273.

Ascocarp whitish to ochraceous, often caespitose, 1.5–2.5 cm. in diam., much lobed and wrinkled; surface unevenly pubescent; gleba brown, marbled with large, light-colored veins; cortical tissue pseudoparenchymatous, cells varying little in size, compressed laterally, occasional cells of surface layer developing into long septate hairs; outer wall of surface cells thickened; subcortical tissue of very loose, irregular, branched hyphae; thickness of peridium 200μ; venae externae very large, branching, irregular in width, filled with loose, branched hyphae; tissue between asci more compact than venae externae, but of coarse structure; venae internae wanting; asci short-stipitate, semiglobose to globose, 72–88 by 72–100μ, 1–4-spored; spores dark brown, globose, 40–48μ, coarsely alveolate, 3 to 9 (generally 6 or 7) alveoli across diameter; epispore 4–8μ thick.

"Under oaks beneath vegetable humus upon a hillside, Laundry Farm, Alameda Co., Calif., March." No. 150, Hk. Col. *Type.*

"In oak forest, San Rafael, Marin Co., Calif., March." "Under oaks, Wire Bridge, Placer Co., Calif., March."
No. 62, Hk. Col. Referred to *T. Magnatum.*

"Growing amongst decaying pine bark in forest, Donner, summit of the Sierra Nevada mountains, 7,000 ft., July; under *Libocedrus*, Towles, Placer Co., Calif."
No. 36, Hk. Col. Referred to *T. puberulum.*

"U. C. Campus, Berkeley, Calif., Jan. 7, 1903."
No. 60, U. C. Col. N. L. Gardner.

"Under *Quercus agrifolia*, U. C. Campus, Berkeley, Calif., Dec. 12, 1904." No. 228, U. C. Col. N. L. Gardner.

"Under *Quercus agrifolia*, U. C. Campus, Berkeley, Calif., Dec. 29, 1904." No. 239, U. C. Col. N. L. Gardner.

"U. C. Campus, Berkeley, Calif., Mar. 20, 1915."
No. 426, U. C. Col. N. L. Gardner.

This species, which is found in the Harkness collection under three numbers, and referred respectively to *T. californicum, T. puberulum*, and *T. Magnatum*, differs so distinctly from the latter two and from all other described species of which record has been found, that it has been allowed to remain under the name of *T. californicum*. There is no indication, whatever, either in the fresh or preserved material examined, of the white flecks considered an important character of the surface of *T. puberulum;* the spores are regularly globular rather than

from short-ellipsoid to globular, the reticulations are not regular in form, and the spores measure 8–20μ instead of 5–9μ in diameter.

T. californicum, so far as collected, differs from descriptions of *T. Magnatum* in size, our species rarely found as large as 2.5 cm., while *T. Magnatum* is said to reach 8 cm. and sometimes more. The asci of *T. Magnatum* are described as only 40–55 by 60–70μ; the spores as short ellipsoid instead of globular, the ascocarp with a distinct base which is absent in ours; and no mention is made of pubescence. The only pubescent *Sphaerotuber* (aside from *T. puberulum* which is sometimes so placed), listed in Saccardo's *Sylloge Fungorum*, is *T. Mougeotii*, which differs in its description from *T. californicum* in being tuberculate, having granulose gleba, 2–4-spored asci, and yellow spores measuring 30–40μ.

Tuber (Oogaster) candidum Hk.

Plate 27

Tuber candidum Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 274, pl. XLV, figs. 32*a*–32*b*.

Tuber Caroli Hk., non Bonnet., Proc Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 274.

Tuber Eisenii Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 275.

Tuber olivaceum Hk., Proc Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 275.

Ascocarp light brown to reddish brown, reaching 2 cm. in diam., semi-globose, nearly even, with one furrow, or several generally connected furrows, mostly on one side, furrows sometimes united into circles forming "eyes" of different color from general ascocarp surface, usually pink in young specimens; surface of ascocarp smooth with small papillae about furrows, or whole surface divided into minute low polygonal areas, occasional colorless septate hairs on surface, particularly at or near mouths of venae externae; veins mostly large, whitish, conspicuous, converging at furrows; cortical tissue minutely and compactly pseudoparenchymatous, outermost cells sometimes lengthened laterally and more or less separated, forming short, knotted, laterally extending hairs or loose network similar to tissue of venae externae; pseudoparenchymatous layer changing within to subcortical layer of laterally elongated hyphae 4–6μ thick; thickness of peridium 200–360μ; venae internae of loosely or more or less compactly arranged hyphae; tissue between asci generally similar, but in some cases becoming more or less pseudoparenchymatous; venae externae filled with loosely interwoven, branched hyphae, 4–6μ thick, opened into furrows of ascocarp surface; asci long or short stipitate, generally ovoid, easily separated from hymenial tissue, 44–52 by 64–80μ, 1–7-spored; spores brown, exceedingly variable in shape from globose-ovoid to long, generally more or less conspicuously pointed at

one end, 22–32 by 28–40μ; surface covered with minute or somewhat coarse spines, 2–3μ in length.

"Under dense clusters of *Ceanothus,* Auburn, Placer Co., Calif., May."
No. 195, Hk. Col. *Type.*

"In clayey soil beneath oaks, Laundry Farm, Alameda Co., Calif., March; Howards, Marin Co., Calif., May."
No. 149, Hk. Col. Referred to *T. Caroli.*

"In sandy places beneath vegetable humus, Auburn, Placer Co., Calif., May." No. 196, Hk. Col. *Type* of *T. Eisenii.*

"Beneath vegetable humus, Auburn, Placer Co., Calif., May."
No. 197, Hk. Col. *Type* of *T. olivaceum.*

"Under Salix, 2–3 inches deep in leaf-covered soil, U. C. Campus, Berkeley, Calif., Jan. 3, 1903."
No. 45, U. C. Col. N. L. Gardner.

"In clay soil under *Salix, Quercus* and *Umbellularia,* U. C. Campus, Berkeley, Calif., Mar. 29, 1903. Under *Eucalyptus,* U. C. Campus, Apr. 1, 1903." No. 91, U. C. Col. N. L. Gardner.

"Same locality and date as preceding (immature)."
No. 92, U. C. Col. N. L. Gardner.

"Under oak in clay soil, Lake Temescal, Oakland, Calif., Apr. 11, 1903." No. 108, U. C. Col. N. L. Gardner.

"In loamy, clayey soil among rocks, Lake Temescal, Oakland, Calif., Apr. 11, 1903." No. 109, U. C. Col. N. L. Gardner.

"In clay soil under *Quercus agrifolia,* Leona Heights, Alameda Co., Calif., Mar. 4, 1905." No. 273, U. C. Col. N. L. Gardner.

"In soil under *Quercus agrifolia,* Thousand Oaks, Berkeley, Calif., Dec. 3, 1913." No. 425, U. C. Col. H. M. Gilkey.

"Under *Salix,* U. C. Campus, Berkeley, Calif., Mar. 27, 1913."
No. 442, U. C. Col. N. L. Gardner.

"Under *Quercus agrifolia,* U. C. Campus, Berkeley, Calif., Mar. 27, 1913." No. 443, U. C. Col. N. L. Gardner.

This is the most commonly collected *Tuber* of California, but it will be noticed from the localities cited above that the range of territory in which it has been found is not wide. In some characters it is exceedingly variable, particularly in spore shape and sculpturing, in the tissue of the gleba, and in the surface of the ascocarp. It was thought possible at first to separate at least two forms, but study of a larger amount of material has shown that there is no apparent definite interrelation of these characters, and that varying intermediate forms are found. For example, in No. 108 of the University of California collection a verrucose ascocarp is associated with very loose hyphal structure of the hymenium. No. 195 of the Harkness collection, on the other hand, is perfectly smooth except about the furrows, while the hyphae of the hymenium are more or less united, and in places the tissue becomes apparently pseudoparenchymatous. No. 109,

however, has the smooth surface of No. 195 with the hymenial structure of No. 108. The character of the spore surface and the shape of the spores differ markedly in a single specimen. The spines in some cases are slender and very numerous and in others coarser and fewer; while the shape of the spores varies from very globose-ovoid to long-ovoid. In nearly every case, one end of the spore is noticeably pointed and the other rounded. This is particularly conspicuous in sectioned spores, a definite thin spot in the wall at the acute end seeming to be present. No. 425 of the University of California collection has regularly longer spores than the other specimens, though in the latter such long spores are not uncommon, and No. 425 also has many spores of the apparently typical globose-ovoid type. The number of spores in an ascus varies generally from one to four, but in several collections the number is found to reach as high as seven. All the specimens are alike in having one to several undeveloped spores in many of the asci.

The venae externae distinctly converge, not at one point at the base as in the *Aschion* type of the *Tubers* of Europe, but along the whole line of the furrows of the ascocarp. There may be three or four or more such lines of convergence in one specimen, for there are sometimes several separated furrows, occurring on one side or even on opposite sides of the ascocarp. Often, however, only a single, generally branched furrow is present, but this may extend over half the distance around the plant. There is no definite orientation of the ascocarp in the ground in relation to these furrows.

This species comes very near descriptions of *T. rufum* (Fischer, 1897*b*, p. 57) in size, color, converging venae externae, sometimes more than four spores in an ascus, several often remaining rudimentary in other asci, spore often pointed at one end, spore and asci measurements, and spore sculpturing. The surface of *T. rufum* is described, however, as early pubescent, becoming glabrous and covered with small, low, polygonal warts or areas, separated by rather sharply marked furrows. There is no indication in the young specimens of our plants of definite pubescence, though occasional hairs are found even upon the mature ascocarps. Some, however, as previously noted, show division of the surface into polygonal areas. The consistency of the ascocarp of *T. rufum* is described as cartilaginous, becoming horny upon drying. Our specimens, particularly those in alcohol, have the consistency of a pickled green olive. The principal difference, however, between *T. candidum* and *T. rufum* seems to lie in the

arrangement of the venae externae. As described, those of the latter species converge at one point, or at several outward-opening hyphal strands at the base of the ascocarp. No mention is made of furrows, though Tulasne's figures (1851, pl. VI, fig. 2) would indicate that they are present, but if present there is evidently no relation between them and the external openings of the veins. Since the venae externae of our plants open into fissures which are strongly marked, and which may occur upon any part of the ascocarp, it seems best to retain *T. candidum* as a distinct species until more extended data for the European material can be secured.

Tuber (Oögaster) lignarium (Hk.) comb. nov.

Plate 30, fig. 25

Terfeziopsis lignaria Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 279, pl. XLIV, figs. 23*a*–23*c*.

Ascocarp brown, 1.5 cm. in diam., subglobose, somewhat furrowed, surface smooth, gleba white, veins variable in size, conspicuous; cortical tissue pseudoparenchymatous, of very small, irregular, thick-walled cells, changing somewhat abruptly to subcortex of compact but mostly unconnected hyphae; thickness of peridium, 320–360μ; venae internae and tissue between asci compact, of generally unconnected hyphae, but latter tissue pseudoparenchymatous in places; hyphae 4–6μ; venae externae few, variable in size but generally very wide at opening and at various places in ascocarp, filled with loose, tangled, branching hyphae, these often breaking away, leaving long canals through interior of ascocarp; asci long-stipitate, semi-globose and more or less cylindrical, 40–52 by 60–72μ, 2-, 3-, or 4-spored, spores light brown, globose-ellipsoid to globose, 20–32μ, surface covered with slender spines with recurved tips, 46μ in length.

"Among oaks in sandy pasture, Auburn, Placer Co., Calif., June."
No. 206, Hk. Col. *Type*.

This is probably the species examined by Harkness and described under *Terfeziopsis lignaria*, the globose or ovoid spores with recurved spines being characteristic; but the measurements in the material which I examined do not agree with the recorded Harkness measurements, and venae externae, though few, are conspicuous. These perhaps open to the surface regularly in furrows, but so little material is available for study that this point cannot be accurately determined. Since venae externae are present, and all other characters are typically those of *Tuber*, the species has been placed under that genus.

This species differs from *T. candidum* principally in completely smooth surface, fewer venae externae, these much enlarged in places and becoming open, and in the globose or nearly globose spores with somewhat curved spines. There are other less tangible characters which are difficult to describe but which tend distinctly to separate the two species. The color of the ascocarp in the alcoholic specimen of *T. lignaria* is shining bluish black, with white gleba; while in all alcoholic material of *T. candidum*, both in the Harkness and University of California herbaria, the ascocarp surface is somewhat reddish brown with lighter brown gleba.

T. lignarium apparently does not come near any described form, its spore shape and character together with the smooth surface of the ascocarp and the few venae externae distinguishing it. Very few Sphaerogasters have been described, and most of these are apparently little known (Paoletti, 1889, p. 885); of described Oögasters, none were found with measurements cited as nearly globose as those of *T. lignarium*.

Piersonia Hk.

Ascocarp subglobose; gleba with wide or narrow strands of sterile tissue separating irregular chambers lined with hymenium, latter sometimes appearing as colored dots on cut surface, connected with exterior by narrow venae externae; latter short or forming long canals through gleba, lined with more or less conspicuous paraphyses, some developing into branched tangled hyphae filling veins; hymenial chambers variously shaped by inward projecting branches of interhymenial tissue; asci and paraphyses arranged in more or less regular palisade, crowded, asci often deformed from crowding, generally somewhat club-shaped, 1 to 4-spored, some spores often not maturing; paraphyses fascicled between asci, somewhat swollen at tips.

The genus *Piersonia* is distinguished from all other genera of the Tuberales in having the asci in chambers which open to the exterior of the ascocarp by long sterile canals. These canals are lined with paraphyses which continue into and throughout the hymenium; and are perhaps approximated or at least foreshadowed in the inward projecting portions of ascocarp surface in *Hydnotrya*, these sometimes extending for long distances into the gleba where they open to the hymenium, the swollen-tipped hyphae of the surface showing gradual transition into paraphyses. However, the fascicled paraphyses in the venae externae of *Piersonia bispora*, with the presence of occasional undeveloped asci, would indicate the possible origin of the sterile

canals as formerly fertile canals which have lost their asci. The spores of the species belonging to *Piersonia* are characteristic, for though alveolate sculpturing is not unusual in the Tuberales, in this case the walls of the alveoli are sometimes as thick (generally one-half as thick) as the diameter of the alveolar cavity, making the epispore appear continuous, with regularly placed, generally hexagonal depressions. These are apparently arranged in definite concentric circles, the centers occurring upon two opposite sides of the spore.

Fischer described the genus *Piersonia* in the *Botanische Zeitung* (1908), Heft VIII and IX, pp. 149–154, from No. 126 (since named *P. bispora*), of the University of California cryptogamic herbarium. His illustrations, pl. VI, figs. 5–10, picture well the characteristics of that species. The conception of the genus as above described will be found to be practically that of Fischer.

Ascocarp 1–1.5 cm. in diam.; gleba showing orange-colored spots; sterile tissue of gleba forming veins, generally narrower than hymenial areas; asci 1–4- (generally 4-) spored ..... *Piersonia alveolata.*

Ascocarp reaching 8 cm. (generally 6) in diam.; gleba without orange-colored spots; sterile tissue of gleba generally broader than hymenial areas, not forming distinct veins; asci 1–2- (rarely more) spored..... ..... *Piersonia bispora.*

Piersonia alveolata Hk.

Plate 28, figs. 1, 2, 3, 4

Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 275.

Piersonia scabrosa Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 275.

Hydnobolites excavatum Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 266.

Pachyphlocus ligericus Hk. non Tul., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 269.

Ascocarp white, becoming yellow or brown, 1.3 cm. in diam. slightly lobed, surface scabrous, sometimes pubescent; gleba yellowish with orange-colored dots, separated by lighter-colored veins; outer cortical tissue of branched intertangled hyphae, often with more or less regular globose thickenings, sometimes so close and even as to make hyphal thread appear like string of beads; hyphae often projecting from surface, forming hairs; tissue beneath other hyphae becoming pseudoparenchymatous, of distinctly angled cells reaching 20μ in diameter, cells becoming smaller within, changing to subcortical tissue of compactly arranged, sometimes connected hyphae running parallel to surface of ascocarp; thickness of peridium, 220–600μ; venae externae generally short, lined with paraphyses, filled with loose, branched hyphae similar to outer cortical tissue, inner hyphae less

thickened than outer; venae internae much branched, broadened at angles, varying in width but mostly slender, of compact hyphal structure similar to subcortex, becoming pseudoparenchymatous in places; asci borne in distinct large "nests," generally irregularly bent or variously shaped by inward extending branches of venae internae; asci generally long-stipitate, crowded, club-shaped, more or less deformed, 64–72 by 80–104μ, separated by fascicled, swollen-tipped paraphyses, 1–4-spored (generally 4-spored); spores globose, 22–36μ, yellow or brown, minutely alveolate, walls of alveoli half as wide as alveolar cavities, 10–14 across diam.; spores irregularly arranged in ascus.

"Beneath *Ceanothus*, Auburn, Placer Co., Calif., May."
No. 183, Hk. Col. *Type.*
"In forest, Auburn, Placer Co., Calif., June."
No. 201, Hk. Col. *Type P. scabrosa.*
"Under vegetable humus in sandy ground, Auburn, Placer Co., Calif., May." No. 189, Hk. Col. *Type Hydnobolites excavatum.*
"Under pine trees in sandy soil, Towles, Placer Co., Calif., May."
No. 44, Hk. Col. Referred to *Pachyphlocus ligericus.*

This species is characterized by very large areas of hymenium which cause the colored dots in the gleba mentioned by Harkness (1899, p. 275), by narrow venae internae, generally 4-spored asci, and small ascocarp. Apparently, too, the venae externae of this species are much shorter than those of *P. bispora*, and do not form the long canals described by Fischer for that species (1908, pp. 149–154), though this point has not been determined satisfactorily for the reason that the Harkness material is more or less granular at the present time, and perfect sections have not been obtained.

Harkness separated his two species upon the characters of ascocarp color and spore measurement. Nothing in regard to the former can be determined from the alcoholic material, but in the specimens sectioned and examined, absolutely no difference can be found in spore size. In both, the size varies from 22–36μ, those from 30–36μ predominating. Evidently some error occurred in recording the Harkness measurements, for these do not agree with his. Under the numbers 189 and 44 of the Harkness collection, named respectively *Hydnobolites excavatum* and *Pachyphlocus ligericus* (Harkness, 1899, p. 266 and p. 269) were discovered material of *Piersonia*. It is impossible to tell from the descriptions of the two species mentioned whether or not the plants examined by Harkness are the ones now found under the same numbers. His description of *Hydnobolites excavatum* with cavernous gleba and eight-spored asci would indicate that another

plant was under consideration. However, in the slide which he left of No. 189, the section is clearly of *Piersonia*. No slide of *Pachyphloeus ligoricus*, so-called, is found, so whether the discrepancy here was simply a result of accidental shifting of labels or confusing of specimens, can not be determined. The fact that the date and the locality for the material under both of these names, as well as of the two Harkness *Piersonias*, are almost identical, may or may not be significant, as much of the Harkness collection was made in Placer County.

No. 44 exhibits all the characters of *Piersonia alveolata* as previously described, but the material of No. 189 is badly worm-eaten and the resulting stimulated growth of tissue, in the form of coarse, colored hyphae, has so obscured the structure that it is impossible to determine with certainty the relation of venae externae to the gleba, and the size of the venae internae. The asci, too, have for the most part, lost their spores, so that the number in an ascus is uncertain. Consequently it is difficult to place this species exactly, but the structure, so far as it can be made out, is like that of *P. alveolata*.

Piersonia bispora sp. nov.

Plate 28, fig. 5

Piersonia (unnamed), Bot. Zeit., 1908, Heft. VIII, IX, pp. 149–154, pl. VI, figs. 5–10.

Ascocarp reaching 8 cm. in diam. (generally about 6 cm.), "ferruginous with occasional white patches;" surface scabrous, sometimes somewhat pubescent; gleba white without dots; outer cortex coarsely and irregularly hyphal, irregularly thickened hyphae often projecting in form of hairs; hyphae of subcortex more slender than those of cortex, compactly arranged, more or less parallel; thickness of peridium, 360–600μ; venae externae forming long, more or less connected, winding canals through gleba, lined with fascicled, swollen-tipped paraphyses, some extending into canal and forming coarse, loose, branched hyphal structure similar to outer cortex; venae externae ending in small chambers lined with asci; main venae internae much broader than hymenial areas, composed of loosely or somewhat compactly arranged hyphae, rarely becoming pseudoparenchymatous; asci club-shaped, long-stipitate, 60–70 by 76–92μ, 1–2- (rarely more) spored, separated by fascicled, somewhat swollen tipped paraphyses; spores globose, yellow or brown, minutely alveolate, walls of alveoli as wide or one-half as wide as alveolar cavities, 10–11 alveoli across diameter; spores 28–30μ, irregularly arranged in ascus; paraphyses 6–8μ at tip. "Odor of plant at first resembling desiccated cocoanut, changing as plant dries, to that of strong cream cheese."

"Under *Pinus radiata*, in hard soil, about one-half exposed; U. C. Campus, Berkeley, Calif., Apr. 27, 1903."
No. 126, U. C. Col. *Type*. N. L. Gardner.
"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., May 24, 1903."
No. 152, U. C. Col. N. L. Gardner.

Material under No. 126 was sent to Fischer, who described and figured it without a name in the *Botanische Zeitung* (1908). This species differs from *Piersonia alveolata* Hk. in the smaller hymenial areas with thicker sterile structure between, somewhat smaller asci with fewer spores, much greater size of the ascocarp, and probably in the very long winding canals through the gleba, though the failure to secure perfect sections of *P. alveolata* leaves this point somewhat doubtful. The gleba, in cut surface, instead of appearing veined with large hymenial areas lying between, as in *P. alveolata*, presents the appearance of a compact structure occasionally interrupted by comparatively small ascus-bearing areas. The sterile tissue in places becomes narrow enough to be considered veins, but generally is wider than the fruiting tissue. The orange-colored dots described by Harkness in *P. alveolata* are absent in *P. bispora*. Since the "dots" are merely the "nests" of asci, the color being due to the crowded masses of spores, this difference in the two species can be explained by the smaller ascus-bearing areas with consequently fewer asci, and by the smaller number of spores maturing in an ascus, making the whole mass of spores much less conspicuous.

Through the long venae externae, the paraphyses which line the walls are found to be quite regularly fascicled, and what appear to be undeveloped asci are occasionally found. The explanation, then, of the peculiar grouping of the asci in distinct areas within the ascocarp, may be simply the loss of asci from the walls of the original folds, and the closing together of these walls to form narrow canals.

Geopora Hk.

Ascocarp tomentose, irregular in shape, varying from simply lobed to very complexly folded, folds loose and easily separable or more or less united; inner cavity originally single, but divided by infolding of wall or by projections from inner surface into narrow labyrinthine canals, continuous or partitioned into chambers by uniting of folds; asci and paraphyses arranged in palisade on inner side of folds, hymenium rarely opening to exterior of folds or ascocarp; asci cylindrical to club-shaped; spores ellipsoid, smooth, colorless, 1- or incompletely 2-seriate.

A. Asci cylindrical to club-shaped, not constricted nor annulate between spores.
Ascocarp rarely exceeding 2.5 cm. in diam., whitish to brown, simply lobed to closely folded; paraphyses slightly longer than asci, terminal cells swollen, 2–6μ thick ..... *G. Harknessii.*
Ascocarp averaging 1.5 cm. in diam., dark brown, somewhat lobed, folded within; paraphyses equal in length to asci, terminal cells swollen, 5–8μ thick ..... *G. Cooperi.*
Ascocarp 4–10 cm. in diam., reddish brown; slightly lobed; closely folded within, generally enclosing tomentum-lined cavity; paraphyses a little shorter than asci, terminal cells slightly swollen, 6μ thick..... *G. magnifica.*
B. Asci cylindrical, constricted, with annulate thickenings between spores.
Ascocarp 2–2.5 cm. in diam., much wrinkled; loosely folded within; paraphyses equal in length to asci; terminal cell not swollen, 4–5μ thick..... *G. annulata.*

Geopora Harknessii Fischer

Plate 30, fig. 37

Botanische Zeitung, 1908, p. 157.
Pseudhydnotrya Harknessii Fischer, in Engler und Prantl, Die natürlichen Pflanzenfamilien (1897), I Teil, Abteilung 1, p. 282.
Pseudhydnotrya carnea Hk., Proc. Cal. Sci., 3d ser., vol. 1, no. 8 (1899), p. 267, plate XLIII, figs. 16*a*–16*b*.
Pseudhydnotrya nigra Hk., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8, p. 267.

Ascocarp light to dark brown, without definite point of attachment of mycelium, whole ascocarp at first enclosed in dense mass of brown branched hyphae; 0.7–4 cm. in diam.; varying in shape from slightly lobed to much folded, folds often extending far into interior; surface more or less verrucose, tomentose, with long coarse hairs; interior chamber comparatively simple to exceedingly irregular and consisting of long, connected labyrinthine canals, due to infolding of or projections from wall; folds and projections mostly easily separable but sometimes more or less connected; surface hairs continuing on infolded cortex, making folds appear as if filled with loose hyphal tissue; folds sometimes so closely crowded that tips of two layers of paraphyses meet; tissue of external wall and folds more or less pseudoparenchymatous between hymenium and tomentum of surface; outer cells of cortex colored and larger than inner colorless cells; asci cylindrical to somewhat club-shaped, not constricted between spores, rounded or somewhat pointed at apex, 16–28 by 140–200μ; spores smooth, 1- or incompletely 2-seriate, globose-ellipsoid to long cylindrical with rounded ends, 10–16 by 18–22μ; paraphyses colorless, terminal cell swollen, 2–6μ thick, little longer than asci.

"Under shrubs among vegetable humus, Mill Valley, Marin Co., Calif., April." No. 1, Hk. Col. *Type?*
"Among shrubs, Auburn, Placer Co., Calif., May; under rocks, Mill Valley, Marin Co., Calif., April."
No. 181, Hk. Col. *Type* of *Pseudhydnotrya carnea*, Hk.

"Under shrubs in firm ground, Auburn, Placer Co., Calif., Nov. to Apr." No. 216, Hk. Col. *Type* of *Pseudhydnotrya nigra*.
"Under 3–8 inches of decaying pine needles, over sand, Golden Gate Park, San Francisco, Calif., Dec. 22, 1901."
No. 3, U. C. Col. W. A. Setchell and C. C. Dobie.
"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Jan. 3, 1903."
No. 42, U. C. Col. N. L. Gardner.
"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Jan. 3, 1903."
No. 43, U. C. Col. N. L. Gardner.
"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Jan. 3, 1903."
No. 44, U. C. Col. N. L. Gardner.
"Under pines, Golden Gate Park, San Francisco, Calif., Dec. 24, 1902." No. 52, U. C. Col. N. L. Gardner.
"Under needles of *Pinus radiata* on top of ground, U. C. Campus, Berkeley, Calif., Feb. 25, 1903."
No. 80, U. C. Col. N. L. Gardner.
"Under *Pinus Pinaster*, Golden Gate Park, San Francisco, Calif., May 9, 1903." No. 142, U. C. Col. N. L. Gardner.
"Under *Pinus Pinaster*, Golden Gate Park, San Francisco, Calif., Nov. 6, 1903." No. 153, U. C. Col. N. L. Gardner.
"Under *Pinus Pinaster*, Golden Gate Park, San Francisco, Calif., Nov. 6, 1903." No. 154, U. C. Col. N. L. Gardner.
"In sand under *Pinus Pinaster*, Golden Gate Park, San Francisco, Calif., Oct. 15, 1904." No. 206, U. C. Col. N. L. Gardner.
"Under pines, Ingleside, San Francisco Co., Calif., Oct. 29, 1904."
No. 207, U. C. Col. N. L. Gardner.
"Ingleside, San Francisco Co., Calif., Feb. 13, 1915."
No. 414, U. C. Col. N. L. Gardner.

This seems to be the most common representative of the Tuberales about the San Francisco Bay region, and the comparative abundance in which material has been collected has made possible definite observations in regard to the constancy of its characters. The ascocarp is found to vary greatly in form, from almost even with a comparatively simple, closed, inner cavity somewhat similar to that of *Peziza* or *Hydnocystis*, to distinctly folded with the cavity apparently very complexly divided. The apparent partitions are discovered to be infoldings of the outer wall or projections from the inner wall, generally very irregularly lobed and often fitted closely together. They are rarely united at points, but usually are very easily separable; and the cavity is found to be composed of labyrinthine canals which, except rarely near the cortex, are all connected. All stages are found between the ascocarps with nearly simple cavities and those with the central hollow represented by labyrinthine canals. In some cases, one side of the ascocarp is simply infolded, the two walls of the fold not in contact; in others there may be several infoldings which become closer as

the projections from the wall into the interior produce pressure from within. However compact the structure of the ascocarp seems to be, however, with the various projecting folds fitted closely together, a slit through one side of the cortex enables it to be opened, nearly all the folds separating easily from each other. In a very few cases, openings from the hymenium to the surface of the ascocarp were found. Whether these exist in the early stages or occur as a result of development has not yet been determined.

Other variable characters in this species are color, from very light to dark brown; surface, whether distinctly verrucose or smooth; size and shape of spores; and size and shape of paraphyses. The first three of these characters are found to vary in plants of the same collection, and the irregularity of spore shape and size is constant in all the plants studied. The variability of paraphyses, however, seems due to another cause. In the half-specimen labeled *Pseudhydnotrya Harknessii* in the Harkness collection, and which may be half of the type specimen of that species, though it is not so indicated, occasional clusters of paraphyses are discovered which have the three or four terminal cells enlarged (measuring 12–14μ) and colored. The paraphyses being so swollen are apparently fascicled between the asci, and some have elongated above the latter, forming coarse brown hairs. The hymenium and the surface of the ascocarp are apparently connected in places, though from the scanty material at hand it is impossible to determine definitely this point. Those which appear to be normal paraphyses are colorless, little longer than the asci and have only the terminal cell swollen, this measuring 2–6μ at the tip. In only two other cases have paraphyses been found which differ from the latter description. One is that of an ascocarp which has been attacked by insects, and the other of an ascocarp badly infested with *Nigrosphaeria Setchellii* (Hk.) Gardner (1905). In both these cases colored and much enlarged paraphyses occur in close proximity to the affected portion of the plant, while all others are small and colorless. It is possible in the specimen labeled *Pseudhydnotrya Harknessii* that both the external openings and the large paraphyses are the result of an abnormal condition in the ascocarp, although, as previously stated, it is impossible to determine this satisfactorily from the small amount of material available. The paraphyses of *Pseudhydnotrya Harknessii* were originally described as 7–14μ thick at the tip (Fischer, 1897*a*, p. 282), but since those measuring 2–6μ appear to be the normal ones, occuring in all the plants studied, while the larger ones are rare and found under apparently pathological

conditions in parts of occasional plants, I have not mentioned the latter in the specific description.

It will be noticed that the spore measurements indicated in the preceding description of *Geopora Harknessii* do not agree with those given by Harkness for *Pseudhydnotrya Harknessii* (25–28 by 14–18μ), though they correspond closely to those cited for *P. carnea* (22 by 15). However, careful examination and measurements of the spores failed to reveal any differences in shape and size in the three species of *Pseudhydnotrya* cited by Harkness. Gardner in a study of *Nigrosphaeria Setchellii* (1905, p. 178) discovered in this species a similar discrepancy in spore sizes as he found them and as they were indicated by Harkness.

The specimens in the Harkness collection labeled *Pseudhydnotrya Harknessii*, *P. carnea*, and *P. nigra*, are found to differ in minor respects, but since such a wide variation exists in a single species, and since representatives of all the forms mentioned above have been discovered in one collection, it seems best to unite the three under one specific name.

Many of the ascocarps of *Geopora Harknessii* are found to be infested with *Nigrosphaeria Setchellii* (Hk.) Gardner (Gardner, 1905). The perithecia of the latter occur as minute black globose bodies closely dotting the surface of the interior folds of the ascocarps of the host. So far as known, the parasite does not occur upon any other host. The exact relation of the two plants has never been definitely determined, but the parasite apparently does little injury. Except for the few cases previously mentioned of stimulated growth of paraphyses about the perithecia of the parasite, no difference can be found in the tissues of infested and non-infested ascocarps of *Geopora Harknessii*.

Geopora Cooperi Hk. (?)

Plate 30, fig. 22

Bull. Cal. Acad. Sci., vol. 1, no. 3, p. 168, 1885.
Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 270.

Ascocarp dark brown, 1.5 cm. in diam., somewhat lobed; surface verrucose, clothed with tangled, coarse, dark brown, septate hairs; cortex pseudoparenchymatous; outer cells large with slightly thickened walls; inner cells elongated toward center, changing abruptly to hyphal tissue; cavity of ascocarp dissected by large, loose, mostly easily separable folds and by projections from inner wall into connected labyrinthine canals; pseudoparenchymatous tissue and hairs of

cortex running through center of folds; asci cylindrical to somewhat club-shaped, gradually tapering to long stipe; asci not constricted between spores, rounded at apex, 24–28 by 200–220μ; spores globose-ellipsoid, 17–21 by 20–24μ; paraphyses with terminal cell swollen, 5–8μ thick, about equal in length to asci.

"Under *Pinus radiata*, U. C. Campus, Berkeley, Calif., Dec. 12, 1904." No. 231, U. C. Col. N. L. Gardner.

Material under this number was sent to Fischer who describes it in the *Botanische Zeitung*, 1908, pp. 157–158, and places it with *G. Cooperi*. The specimens he received were not quite mature, and he found the asci shorter (150–190μ) and the paraphyses narrower (5μ) than above described. The spores in the material studied differ in size from those of *G. Cooperi* as described by Harkness, his measurements being 20 by 28μ. However, this difference is no greater than that found in actual measurements of *Pseudhydnotrya carnea* and those cited by Harkness, and the discrepancy in both cases may simply be due to an error in recording. Such other characters as are mentioned in his description agree with those of our species, and it seems best to consider the two identical; though since the type of *G. Cooperi* cannot be found in the Harkness collection at Stanford University and apparently also does not exist in the California Academy of Sciences herbarium, there seems to be no means of definitely deciding this point.

Geopora magnifica, sp. nov.

Plate 30, fig. 35

Ascocarp reddish brown, subglobose, 4–10 cm. in diam., minutely verrucose, densely tomentose, particularly in wrinkles and depressions; comparatively even, with few low lobes and shallow depressions, but surface of cortex occasionally extending far into ascocarp (rarely entirely through) forming a large, clearly defined chamber generally unconnected with hymenium; walls of chamber much folded and covered with tomentose cortical tissue; gleba composed of complex closely folded tissue through center of which runs cortical tissue as two narrow layers of pseudoparenchyma bearing intertangled septate hairs, these two layers sometimes separating for short distances forming small chambers; very rarely openings from hymenium to chambers present; inner walls of folds covered with hymenium, with sometimes numerous short projections making surface appear thickly papillose; hymenium-lined cavity representing single hollow into which much convoluted walls extend, forming numerous labyrinthine canals, later occasionally becoming closed chambers through union of walls; larger folds easily separated, but smaller more or less compactly fitted to-

gether and sometimes united; asci cylindrical, not constricted between spores, 20 by 180μ; spores smooth, 1-seriate, ellipsoid, 14–18 by 24μ; paraphyses a little shorter than asci, slightly swollen, 6μ thick.

"Moraga Ridge, Alameda Co., Calif., Jan. 24, 1915."
No. 412, U. C. Col. *Type*. A. A. Baroteau.

The measurements of paraphyses and spores in this species do not agree with those of Harkness for any of his species of *Geopora*. Aside from the measurements, there is nothing to exclude this species from *G. Cooperi* as described by Harkness, but there are no characters there mentioned that are particularly characteristic of this species. It differs from *G. annulata* in size, comparatively even surface, very definite hollow opening to exterior, unconstricted asci, and broader paraphyses. It differs from the plants which I have referred with a question to *G. Cooperi*, in size, regularity of surface, central hollow, smaller asci, spores less globose-ellipsoid, and paraphyses with less conspicuously swollen tips.

This is the largest of the ascomycetous hypogaei reported from California, being approached in size only by *Piersonia bispora*, which sometimes reaches 8 cm. in diameter. The collector, A. A. Baroteau of Alameda, California, pronounces the plants edible and delicious.

Geopora annulata sp. nov.

Plate 28, fig. 6

Ascocarp reddish brown and black, 2–2.5 cm. in diam., much wrinkled, surface verrucose, densely tomentose particularly in wrinkles, tomentose cortex extending deeply into interior; outer cortical tissue pseudoparenchymatous with large cells; gleba of large, loose folds containing central layer of coarse hyphal tissue continuing from outer cortex, ends of folds free, enlarged; asci cylindrical, strongly constricted with annulate thickenings between spores, rounded at apex, 16–20 by 140–160μ; spores smooth, 1-seriate, globose-ellipsoid, 14–18 by 22–26μ; paraphyses not swollen at tip, 4–5μ thick.

Locality and date, No. 10*b*, Hk. Col. *Type*.
"In sandy ground, Golden Gate Park, San Francisco, Calif., April."
No. 102, Hk. Col.

This species is found in the Harkness collection under the numbers 10*b* and probably also under 102. The type of *G. Cooperi* is cited under the number 106 (Harkness, 1899, p. 270) and it is possible that 10*b* represents the type, the number 106 being a misprint. There is

nothing in the description, which is very general, to exclude it except the spore and ascus measurements, which are larger than my findings (26 by 220μ for the asci, and 20 by 28μ for the spores). The measurements given by Harkness for No. 102 (12 by 80 for the asci and 12 by 18 for the spores) likewise debar this material from that species. There is no mention in the descriptions by Harkness of either *G. Coopcri* or *G. brunncola* (the type of the latter being cited under No. 102, Harkness, 1899, p. 270) of the peculiar characteristics of Nos. 10*b* and 102 as I found them; and therefore I feel justified in the supposition that in the various handling received by the Harkness material, labels have been shifted or specimens otherwise confused, and 102 probably does not represent the type of *G. brunncola*. The latter is known to us only in the brief description of it by Harkness (Proc. Calif. Acad. of Sci., 3d ser., vol. 1, no. 8, p. 270), and therefore its present status cannot be defined.

Under 10*b*, entire specimens are found; but under 102 the material is discovered to be in three or four pieces each measuring about 18 mm. in diameter. Whether these all belonged originally to a single specimen or to more cannot be decided with certainty, and therefore the size of the specimen cannot be definitely determined. The material under 102 also has been attacked by the larvae of some insect, and very little remains from which to determine the structure. However, as far as it can be made out, it resembles 10*b* very closely, the measurements are identical, and the peculiarly constricted internally annulate asci, found in no other species observed, are very conspicuous in both.

HYDNOTRYOPSIS, gen. nov.

Ascocarp subglobose, compact, more or less lobed and wrinkled, without external opening; cortex sometimes extending deeply into interior; gleba composed of minute, irregular folds, more or less joined, forming complex system of veins separating canals and chambers; hymenium of regular palisade of asci, lining walls of canals and chambers; asci cylindrical, 8-spored; spores ellipsoid, papillose.

This genus belongs, apparently, in phylogenetic line with the angiocarpous forms, *Geopora* and *Balsamia*, for very careful search has failed to reveal external openings from the hymenium. The exceedingly fine folding of the gleba and wrinkling of the surface made this point a difficult one to determine, but sufficient material was available to make sections of every portion of the ascocarp. The closest, most

careful study possible was made of a large series of these, and in no case was there any indication of external communication from the hymenium.

A cross-section of the ascocarp suggests the structure of *Choiromyces*, but descriptions and illustrations show the hymenium of the latter to consist of long, irregularly bent bands, the halves running more or less parallel and the ends often joined, the space between the free tips of the two rows of palisade filled with hyphal tissue. The sterile veins separating the bands appear irregular in shape and generally much wider than the bands. In the Californian specimens, the whole ascocarp is made up internally of an elaborate system of very narrow folds densely covered with hymenium. The folds, which form the sterile veins, are remarkably regular in width. These are often fitted so closely together that the free ends of the two rows of asci are nearly or quite in contact, but in places the folds are less closely associated and leave comparatively wide, open chambers. Sometimes the folds are united at points, closing the chambers, but as a rule they are unconnected and can be separated for long distances through the ascocarp. The canals, when wide, are generally irregular in shape, due to inward projecting, short branches of the venae internae. The spores are smaller than for any described species of *Choiromyces*, and are globose-ellipsoid instead of globose, while the asci are cylindrical rather than club-shaped. The structure of the interior comes near that of *Geopora*, but the glabrous surface, sculptured spores, more minute and compact folding, uniform veins originating from the subcortical layer rather than from the infolding of the cortex as they are formed generally in *Geopora*, and the much more common presence of short chambers, seem sufficient basis for the separation of the two.

While *Hydnotryopsis* differs from *Hydnotrya* in the absence of venae externae and the presence of a conspicuous system of venae internae, the general arrangement of empty canals and chambers lined with hymenium in regular palisade, the walls of the canals apparently formed by more rapid internal than external growth of the ascocarp, is like that of *Hydnotrya;* and the two have apparently reached the same stage in parallel lines of development. Though little preserved material exists from which to describe the genus, it seems sufficiently distinct from all other genera of the Tuberales to justify its position. It is to be hoped, however, that further collections and data may be obtained.

Hydnotryopsis Setchellii gen. et sp. nov.

Plate 30, figs. 21, 36

Stephensia bombycina Hk. non Tul., Proc. Cal. Acad. Sci., 3d ser., vol. 1, no. 8 (1899), p. 268, pl. XLIV, figs. 18*a*–18*c*.

Ascocarp clay-yellow, subglobose, compact, without mycelial tuft at base, 1.5 cm. in diam., lobed, lobes minutely and deeply wrinkled, cortex occasionally extending so deeply into interior as almost to reach opposite side; surface minutely scabrous; gleba composed of very small, irregular folds, sometimes joined, forming complex system of narrow branching veins separating long, labyrinthine, more or less connected canals and chambers not opening externally, lined with hymenium formed of regular palisade of asci; outer cortical tissue pseudoparenchymatous, becoming hyphal within; veins hyphal, originating from inner cortical tissue; asci cylindrical, 8-spored, 12 by 40μ; globose-ellipsoid, regular in size, 10–11 by 12–13μ, very minutely papillose.

"Found in forests, March. No locality." No. 173, Hk. Col. *Type.*

This species is found in the Harkness collection under the number referred by Harkness to *Stephensia bombycina* (1899, p. 268). It will be seen from the preceding description, however, that it differs from *Stephensia,* as described, in the absence of venae externae; of regular, radial arrangement of the venae internae; of a basal cavity; and of smooth, globose spores.

Delastria Tul.

Ascocarp irregularly subglobose, sometimes lobed, scabrous or finely floccose; cortex distinct, extending into gleba as venae internae; latter anastomosing in reticulate form, separating gleba into rounded, hymenium-bearing areas; venae externae wanting; asci irregularly arranged in hymenial areas, often deformed, club-shaped or long ellipsoid, sometimes curved, 2- to 4-spored; spores globose, alveolate, with angles extended to form spines.

This genus differs from *Tuber* in its lack of venae externae and in the reticulate arrangement of the venae internae, forming well-marked rounded areas of hymenium. The first suggestion of such arrangement is found in *Heterogenea* of the genus *Genea.* Here the hymenium, which in *Hydnocystis* and *Eugenea* consists of an even uninterrupted layer of asci and paraphyses, is separated by strands of sterile tissue into distinct "pockets," in which, because of the rounded angles, the originally regularly placed asci and paraphyses become irregular and crowded. In *Genea cerebriformis* extreme lobing of the

aseocarp causes more or less doubling of the hymenium, further complicating the arrangement, the highest development of which is perhaps found in *Delastria*. The spores of *Delastria*, with the sharply projecting angles of the alveoli, resemble somewhat those of *Hydnobolites*, but the two genera are easily separated by the absence and presence, respectively, of venae externae, and by the general characters of the aseocarp.

Delastria rosea Tul.

Tulasne, Ann. Sc. Nat., 2nd ser., vol. 19 (1843), p. 379.

Aseocarp 1–1.5 cm. in diam., subglobose, somewhat convolute, surface minutely scabrous, caused by irregularly projecting cortical cells; veins of gleba indistinct like water marks, dividing it into roundish areas; cortex hyphal to pseudoparenchymatous, compact, 80μ thick; sterile veins of irregular hyphae joined to form pseudoparenchymatous structure; cells sometimes reaching width of 20μ; asci semi-globose, 36–52 by 48–60μ, or very much elongated, reaching length of 120μ, width 40μ; spores globose, 22–30μ, alveolate and spiny, 2–7 alveoli across surface, spines somewhat blunt, thick, 5μ in height.

"Under shrubs among vegetable humus, Auburn, Placer Co., Calif., May." No. 182, Hk. Col.

While for this genus only one species is reported, a great amount of variation apparently exists. Fischer's illustration (1897*a*, p. 317) represents a plant whose veins are principally hyphal, whose spores have generally 6–7 alveoli across the diameter, the angles projecting as sharp-pointed needles, and whose cortex is more or less pseudoparenchymatous of somewhat elongated narrow cells. The spore diameter cited is 30–40μ. Tulasne's illustration (1851, pl. XVI, fig. 1) indicates, on the other hand, a much looser, irregular structure through the venae internae, which is also seen in an Italian specimen, in the University of California herbarium, from Mattirolo. The spores of the latter agree in size with the measurements given by Tulasne and Fischer (30–40μ). Our specimens have a compact structure through the cortex and outer veins similar to that of Fischer's figure, though the hyphae in ours are entirely unconnected through the cortex, becoming more or less united in the venae internae, in places even pseudoparenchymatous with large cells. The spores in ours, however, are smaller than of any of the above, measuring 22–30μ, and the number of alveoli across the diameter is more often 3–5 than more, though occasionally 7 are found. The spines are distinct (they are

not figured by Tulasne) but are shorter, fewer, and more blunt than in the Mattirolo specimen and than illustrated by Fischer.

There is no indication now of rose-color in the cut surface of the Californian material, but at the time of collection, this, according to Harkness, was very conspicuous.

The differences between these plants and those of Europe do not seem sufficient for specific separation, but the Californian specimens may at least be considered a geographical variety until the extreme variation in the whole genus is worked out more thoroughly.

Hydnobolites Tul.

Ascocarp subglobose, generally lobed or folded; cortex pseudoparenchymatous, changing to hyphal tissue toward hymenium, or whole structure of ascocarp more or less pseudoparenchymatous; canals of ascocarp labyrinthine, penetrating deeply into gleba, lined with pseudoparenchyma; opening generally between folds of ascocarp surface; venae internae wanting; asci somewhat irregularly arranged between canals, ellipsoid to pyriform, 8-spored; spores globose, alveolate, angles of alveoli projecting outward as spines; spores irregularly arranged in ascus.

This genus, which Fischer (1897*a*) formerly placed under the family Terfeziaceae of the order Pleetascales, he has since removed to the Tuberales and placed in phylogenetic line with *Tuber*. The spores of the species in this genus resemble those of *Delastria rosea* in having the angles of the alveoli projecting in the form of needles, but the asci are 8-spored rather than 4-spored. The pseudoparenchymatous structure of the canal walls as well as, occasionally, of the whole ascocarp tissue, is characteristic, but is approached in several Californian species of *Tuber* in which the venae internae become more or less pseudoparenchymatous.

Hydnobolites californicus Fischer

Plate 30, fig. 26

Ed. Fischer, in Fedde, Repertorium 7 (1909), p. 194.

Ascocarp of gristly consistency, at first dirty-white, becoming brownish at maturity; 0.5–3 cm. in diam.; slightly to very irregularly folded, canals opening to surface in folds; surface bearing occasional short septate hairs of 2 or 3 cells; pseudoparenchymatous cortex of ascocarp continuing as border of canals, 8μ thick; cells irregular in size, inner generally smaller than outer, changing somewhat gradually to hyphal tissue of interior; hyphae of latter coarse, 4–10μ thick; canals narrow, mostly long, more or less labyrinthine; asci scattered

irregularly through hyphal tissue, irregularly globose-ellipsoid; spores yellowish at maturity, loosely and irregularly arranged in asci, globose, 14–18μ, very coarsely alveolate, angles of alveoli projecting as thick, blunt spines 4μ long; 3–4 alveoli across diameter of spore.

"Under oak, Piedmont Park, Oakland, Calif., Apr. 4, 1903."
No. 106, U. C. Col. *Type*. N. L. Gardner.
"Mt. View Cemetery, Oakland, Calif., Jan., 1903."
No. 110, U. C. Col. N. L. Gardner.
"U. C. Campus, Berkeley, Calif., Feb., 1905; Leona Heights, north of Oakland, Calif., Feb., 1905; Berkeley Hills, Berkeley, Calif., Feb., 1905; Wild Cat Canyon, Berkeley, Calif., April 1, 1905."
No. 278, U. C. Col. N. L. Gardner.

Material under the three numbers mentioned above was examined by Fischer who pronounced Nos. 106 and 278 identical and evidently a new species, since they differed in larger ascocarp, smaller spores, and absence of mycelial tuft at base, from the three previously described species. No. 110, through its somewhat larger spores, approached *Hydnobolites cerebriformis* Tul. in his opinion, perhaps being identical with it (letters of October 11, 1905, and March 27, 1909). He suggested the name *H. californicus* for the first two, and this was later published by him in Fedde, *Repertorium* VII (1909), p. 194.

Study of various specimens of No. 110, and careful comparison with material under the Nos. 106 and 278, reveal the fact that while the spores of the former are at times larger than those of the two latter, this difference is not constant, and otherwise the plants of the three collections seem identical.

Aside from the characters mentioned by Fischer, our plants differ from *H. cerebriformis*, as it is described, in shape of asci and thickness of pseudoparenchymatous cortex, the former of this species being given as less globose-ellipsoid, and the latter measuring 100–120μ. *H. californicus* differs from descriptions of *H. Tulasnei* Hesse in color, narrower hyphae of internal tissue, shape and size of asci, and size of ascocarp and spore, *H. Tulasnei* being described in these points as follows: Surface of ascocarp rose-colored, changing to flesh color at maturity; hyphae 10–14μ; asci pear-shaped to egg-shaped, 70–100μ; ascocarp 1 cm. in diam.; spores 17–21μ. Our species is debarred from *H. fallax* Hesse, as described, by the absence of pseudoparenchymatous tissue in the interior of the ascocarp.

VIII. KEY TO GENERA

A. Ascocarp with distinct external openings from hymenium.
  a. Cavity simple, empty.
    Spores generally smooth ..... *Hydnocystis.*
  aa. Cavity dissected into labyrinthine canals.
    1. Canals connected, filled with hyphae, converging at apex or base.
      x. Canals converging at apex, spores smooth ..... *Pseudobalsamia.*
      xx. Canals converging at apex, spores sculptured ..... *Pachyphloeus.*
    2. Canals unconnected, empty or filled with hyphae.
      x. Canals empty.
        z. Paraphyses forming secondary cortex beyond asci, spores papillose or verrucose ..... *Genea.*
        zz. Paraphyses not forming secondary cortex beyond asci, spores papillose or verrucose ..... *Hydnotrya.*
      xx. Canals filled with hyphae.
        z. Hymenial areas irregularly arranged between canals .... *Eutuber.* (*Tuber*).
        zz. Hymenial areas formed by enlarged ends of canals .... *Piersonia.*

AA. Ascocarp without distinct external openings from hymenium.
  a. Asci and paraphyses arranged in palisade.
    1. Cavity simple, empty ..... *Hydnocystis.*
    2. Cavity dissected into empty chambers or canals.
      x. Canals or chambers mostly connected, ascocarp tomentose, spores smooth ..... *Geopora.*
      xx. Unconnected chambers redissected into connected canals, ascocarp smooth, spores sculptured ..... *Hydnotryopsis.*
  aa. Fruiting areas irregular; cavity wanting.
    Cavity wanting, ascocarp divided into irregular fruiting areas.
      x. Ascocarp comparatively even; asci 4-spored ..... *Delastria.*
      xx. Ascocarp conspicuously lobed; asci 8-spored ..... *Hydnobolites.*

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X. DIAGNOSES OF NEW GENUS AND NEW SPECIES

Hydnocystis californica

Ascomatibus 1 cm. in diam., subglobosis, dilute vel atro fuscis, perfecte clausis, myceliо brunneo septato ramoso cinctis, ad superficiem projectis pyramidatis basi 1.5 mm. diam. instructis; gleba alba; texto superficiali intus per gibbos pseudoparenchymatico, cellularum externarum parietibus lente inerassatis; cellulis externis passim in pilis septatis productis; texto pseudoparenchymatico intus in hyphas transformato et hyphis prorsus ad hymenium eximie angustatis; ascis cylindricis, inter sporas lente constrictis, ad stipitem plus minusve distinctam attenuatis, 16–24 × 240μ, 8-sporis; sporis globoso ellipsoideis, levibus, 18–20 × 22–24μ, 1-seriatis; paraphysibus gracilibus 4–6μ crassis, in longitudine ascos aequantibus aut aliquando ascos leviter irregulariterque superantibus, septatis, apice exigue tumefactis; odorem sacchari usti ostendentibus.

Genea Harknessii

Ascomatibus atro fuscis usque ad atris, 2 cm. diam. compressis, lente lobatis, superficialiter projectis pyramidalibus robustisque basi usque ad 1 mm. altis indutis; caverna ascomatis projectis irregularibus e pariete interne multo dissecta; textis corticis externi pseudoparenchymaticis prorsus ad hymenium hyphas ostendentibus, cellulis externis magnis, obscuris et parietibus crassis; hymenio frequenter duplici, e conjunctione projectorum internorum parietum, a fasciis textorum sterilium cortices conjugentium; ascis cylindricis aut lente clavatis, non inter sporas constrictis, stricte stipitatis, 32 × 225μ; sporis 1- aut imperfecte 2-seriatis, 22–24 × 28μ, superficialiter papillatis; papillis semi-globosis aut exigue truncatoconicis usque ad 4μ latis altisque, vulgo in crassitudine altitudine, et distributione usque in spora eadem variabilibus, paraphysibus 2–8μ diam., sub cortice secundario ramosis.

Genea Gardnerii

Ascomatibus nigris, 1–1.5 cm. diam., multo rugosis plicatisque, superficialiter minute verrucosis; caverna ascomatis valde irregulari ob implicationes sed non saepe ob projecturas parietum; textis corticis externi pseudoparenchymaticis intus in hyphas horizontales anastomosantesque transformatis; hymenio textis sterilibus interrupto; ascis cylindricis aut plus minusve clavatis, inter sporas non constrictis, ad stipitem saepe elongatam attenuatis, 34–42 × 280–425μ, sporis 1-, aut rare imperfecte 2-seriatis, aliquando tantum 3–4 maturantibus, globoso-ellipsoideis, 30–34 × 32–36μ, superficialiter papillis latis (8μ), humilibus et semiglobosis dense vestitis papillis ipsis plus minusve minute papillosis; paraphysibus facie irregularibus cum cellulis nonnullis elongatocylindricis aliis brevibus tumidisque, 3–9μ diam., ramosis.

Genea intermedia nom. nov.

Ascomatibus rubro-fuscis, lente lobatis, ad superficiem papillis rotundatis usque ad 0.3 mm. diam. indutis; caverna fere simplice, pariete interna lobos parvos externos parallelo sequente; corticibus primis et secundis prorsus pseudoparenchymaticis; hymenio raro fasciculis texti sterilis interrupto; ascis cylindricis aliquando inter sporas constrictis, 44 × 300μ; sporis 1-seriatis, globosis, 36μ diam., juvenilibus levibus hyalinisque, maturis asperis papillis semiglobosis, e minutis ad 5μ altis usque in spora singula variantibus, saepe irregulariter anastomosantibus; paraphysibus 4μ crassis inter ascos stricte in fasciculis aggregatis.

Hydnotrya ellipsospora

Ascomatibus purpurascente-brunneis, 1.5 cm. in diam., subglobosis, plicis laxis compositis, superficie minute pilosis; glebae cavernis connectis, latis angustisve, ascis paraphysibusque valliformibus indutis; paraphysibus in hyphis apice paululum tumidis ad foramina distincte transformatis; ascis cylindricis inter sporas non constrictis, 10 × 260μ; sporis 1-seriatis, ellipsoideis 10 × 14μ, minute papillosis; paraphysibus ultra ascos non prominentibus, 2–5μ latis.

Tuber (Eutuber) levissimum

Ascomatibus argillaceo-brunneis, 2 cm. diam., regularibus, superficie levibus; gleba dilute brunnea, venis magnis colore inconspicuis; textis corticis vix pseudoparenchymaticis, hyphis parallelis plus minusve coalescentibus ad hymenium laxe connectis compositis; venis internis compactis, structura ad textas corticis approximatis; ascis subglobosis vel globosis, 50–80 × 70–100μ, 1–4 sporis; sporis dilute brunneis, globoso-ellipsoideis, 32–40 × 36–52μ, alveolatis; alveolis magnitudine et numero in sporis variabilibus, 3–10 × 4–13 trans diam., sculptura 4μ crassa.

Tuber (Eutuber) separans

Ascomatibus plumbeo-purpureis, 1 × 1.2 cm., semiglobosis, convolutis, superficialiter minute verrucosis, venis inconspicuis; textis corticis externi pseudoparenchymaticis interne compacte hyphalibus gradatim transformantibus; venis internis compactis, hyphis parallelis, saepe anastomosantibus, aliquando pseudoparenchymaticis; ascis breviter stipitatis, semiglobosis, 56–68 × 60–92μ, 1–3- (rare 4-) sporis; sporis alveolatis, alveolis 5–10 × 7–11 trans diam.

Tuber (Eutuber) irradians

Ascomatibus fuscis, 1.5 cm. diam., depresso-globosis, paululum lobatis, superficialiter minute verrucosis areolis sparsis crassiore verrucosis; gleba primo alba deinde brunnea; venis paucis parce ramosis, albis; textis corticis pseudoparenchymaticis cellulis ordinibus plus minusve distincte radiantibus ordinatis; textis subcorticis laxe hyphalibus; venis internis hyphis parallelis, separatis laxeque instructis;

ascis aliquando longe stipitatis pyriformibus, elongatis aut subglobosis, 44–64 × 76–92μ, 1–3- (vulgo 1–2-) sporis; sporis ellipsoideis, 36–48 × 40–56μ, alveolatis, alveolis 3–8 × 3–9 (vulgo 7 × 8) trans diam.; sculptura sporarum 4–6μ alta.

Tuber (Eutuber) Gardnerii

Ascomatibus fuscis 1.5 cm. diam., subglobosis leviter convolutis, superficialiter verrucosis; gleba primo alba deinde pallide fusca; venis latis conspicuis, albis; textis corticis crasse pseudoparenchymaticis; textis subcorticis hyphis separatis parallelisque; venis internis hyphis tenuibus, separatis et parallelis; ascis non stipitatis, semiglobosis, raro elongatis, 56–68 × 80–88μ, 1–5-sporis; sporis pallide brunneis, globosis aut elongato-ellipsoideis, 24–30 × 28–48μ, alveolatis, alveolis 3–11 × 5–14 trans diam.; sculptura sporarum 4–6μ alta.

Tuber (Eutuber) argentea

Ascomatibus corneis argenteo-albis areis sparsis colore obscurioribus, 3 mm.–2.5 cm. diam., depressis, irregulariter convolutis et saepe minute rugosis, superficialiter planis aut per trajectus rugarum in areas minutas dissectis, cum pilis brevibus septatis et obtusis; gleba subfusca venis albis ramosisque induta; textis corticis pseudoparenchymaticis aut crasse et laxe hyphalibus; textis subcorticis hyphis laxis et irregulariter positis compositis; venis internis in structura strato subcorticis similibus; venis externis internisque ad junctionem cum pericarpio valde dilatatis; ascis breviter stipitatis estipitatisve, semiglobosis, 64–78 × 76–92μ, 1–4- (vulgo 1–2-) sporis; sporis obscurofuscis, ellipsoideis, alveolatis, alveolis 8–9 × 9–10 trans diam.; sculptura sporarum 4μ alta.

Tuber (Oogaster) lignarium

Ascomatibus fuscis, 1.5 cm. diam., subglobosis, lente sulcatis, superficialiter levibus; gleba alba; venis magnitudine variabilibus, distinctis; textis corticis pseudoparenchymaticis cellulis parvis, irregularibus parietibus crassis compositis; textis subcorticis hyphis compactis, liberis, parallelisque compositis; structura venarum internarum texto subcorticis simili; textis sterilibus hymenii passim pseudoparenchymaticis; hyphis venarum externarum saepe diffringentibus fissuras longas, in interiorem ascomatum efficientibus; ascis longe stipitatis semiglobosis ad fere cylindricis, 40–52 × 60–72μ, 2–3-, aut 4-sporis; sporis dilute fuscis, globoso-ellipsoideis ad globosis, 20–32μ, spinosis, spinis tenuibus, apice recurvatis.

Piersonia bispora

Ascomatibus ad 8 cm. (vulgo 6 cm.) diam., subglobosis, ferruginosis interdum maculas albas ostendentibus, ad superficiem glabris, aliquando parce ciliatis; gleba alba areis coloratis destituta; cortice crasse irregulariterque hyphali, hyphis irregulariter densis saepe ut pilis ultra superficiem prominentibus; hyphis texti subcorticalis gracilibus, compactis, plus minusve parallelis; venis externis longis, labyrinthiformibus, angustis; venis internis plerumque quam areis hymen-

ialibus latioribus, plerumque hyphalibus, raro pseudoparenchymatice transformatis; ascis clavatis, longe stipitatis, 60–79 × 76–92μ, 1–2-(raro 3–4-) sporis, a paraphysibus fasciculatis et apice tumidis separatis; sporis globosis, luteis aut brunneis dense alveolatis, alveolorum parietibus sicut latis aut dimidiis quam cavernis alveolorum, alveolis 10–11 trans diam., sporis 28–30μ; paraphysibus apice 6–8μ diam.; odore plantarum vivarum carnis dessicatae nucis palmae indicae, sed plantarum siccarum casei cremoris aetate provecti simili.

Geopora magnifica

Ascomatibus rubro-fuscis, fere globosis, 4–10 cm. diam., minute verrucosis, dense tomentosis comparative planis lobis paucibus humilibusque sed cortici aliquando in interiore longe (rarissime totaliter) penetrante cavernam magnam plerumque hymenio non continuam formante; parietibus cavernae valde plicatis et textis corticalibus tomentosis indutis; gleba compactis plicis aliquando anastomosantibus composita, plicis textis corticalibus tomentosis completis; ascis cylindricis, inter sporas non constrictis, 20 × 180μ; sporis levibus, 1-seriatis, ellipsoideis, 14–18 × 24μ; paraphysibus quam ascis paululum brevioribus, lente tumidis, 6μ crassis.

Geopora annulata

Ascomatibus rubro-fuscis et nigris, subglobosis aut paululum elongatis, 2–2.5 cm. longis, valde rugosis, superficialiter verrucosis, dense tomentosis, textis corticis externi crasse pseudoparenchymaticis; gleba plicis magnis laxis tenuibusque composita, plerumque textis hyphalibus e cortice descendentibus impleta; finibus plicarum liberis, dilatatis; ascis cylindricis, inter sporas valde constrictis et parietibus valde annulatimque incrassatis, 16–20 × 140–160μ; sporis levibus, 1-seriatis, globoso-ellipsoideis, 14–18 × 22–26μ; paraphysibus apice non tumidis 4–6μ crassis.

HYDNOTRYOPSIS

Ascomata subglobosa compacta, lobata, cortice nonnumquam in glebam profunde penetrante; gleba plicis minutis compactis, et irregularibus, nonnumquam anastomosantibus et fossas longas labyrinthiformesque et cubicula clausa separantibus composita, externe ascis et paraphysibus valliformibus vestita; asci cylindrici, 8-spori; spora globoso-ellipsoidea, minute papillosa.

Hydnotryopsis Setchellii

Ascomatibus argillaceo-luteis, compactis, puncto adjuncto mycelialo destitutis, 1.5 cm. diam., lobatis, minute et profunde rugosis, cortice passim in interiorem profunde penetrante, superficie minute scabrosis; gleba plicis minutis irregularibusque nonnumquam anastomosantibus, venas longas angustas et ramosas fossas labyrinthiformes et cubicula hymenio ascis paraphysibusque valliformibus vestita formantibus composita; textis corticis pseudoparenchymaticis; textis subcorticis venisque hyphalibus; ascis cylindricis, 8-sporis, 12 × 40μ; sporis globoso-ellipsoideis, in magnitudine uniformibus, 10–11 × 12–13μ, minute papillosis.

XI. LIST OF WORKS REFERRED TO

Bucholtz, F.

1903. Zur Morphologie und Systematik der Fungi hypogaei. Annales Mycologici, No. 1.

Corda, A. C. I.

1837. Abbildungen der Pilze und Schwaemme. Icones Fungorum, tom. V, pars. II.

Fischer, Ed.

1897*a*. Tuberineae und Plectascineae, *in* Engler and Prantl, Die natürlichen Pflanzenfamilien, I Teil, Abteilung 1.

1897*b*. Tuberaceen und Hemiasceen, *in* Rabenhorst, Kryptogamen-Flora von Deutschland, V Abtheilung.

1907. Über einige kalifornische Hypogaeen. Ber. der deutsch. Bot. Gesellsch.

1908. Zur Morphologie der Hypogaeen. Botanische Zeitung, Heft VIII, IX.

1909. Diagnosen einiger Fungi hypogaei aus Californien in Fedde, Repertorium VII.

Harkness, H. W.

1899. Californian Hypogaeous Fungi. California Academy of Sciences, 3d series, Vol. 1, No. 8.

1880. Catalogue of Pacific Coast Fungi. California Academy of Sciences.

Kauffman, C. H.

1911. Unreported Michigan Fungi for 1910. 13th Report of the Michigan Academy of Science.

Osterhout, W. J. V.

1896. A simple freezing device. Botan. Gazette, Vol. 21.

Paoletti, J.

1889. Tuberoideae. Saccardo, Sylloge Fungorum, Vol. VIII.

Setchell, W. A.

1910. The Genus Sphaerosoma. Univ. of California Publications in Botany, Vol. IV, no. 5.

Tulasne,

1851. Louis-René and Charles. Fungi Hypogaei.

Vittadini, Carolo.

1831. Monographia Tuberacearum.

PLATE 26

Diagram of phylogenetic relationships in the Tuberales.

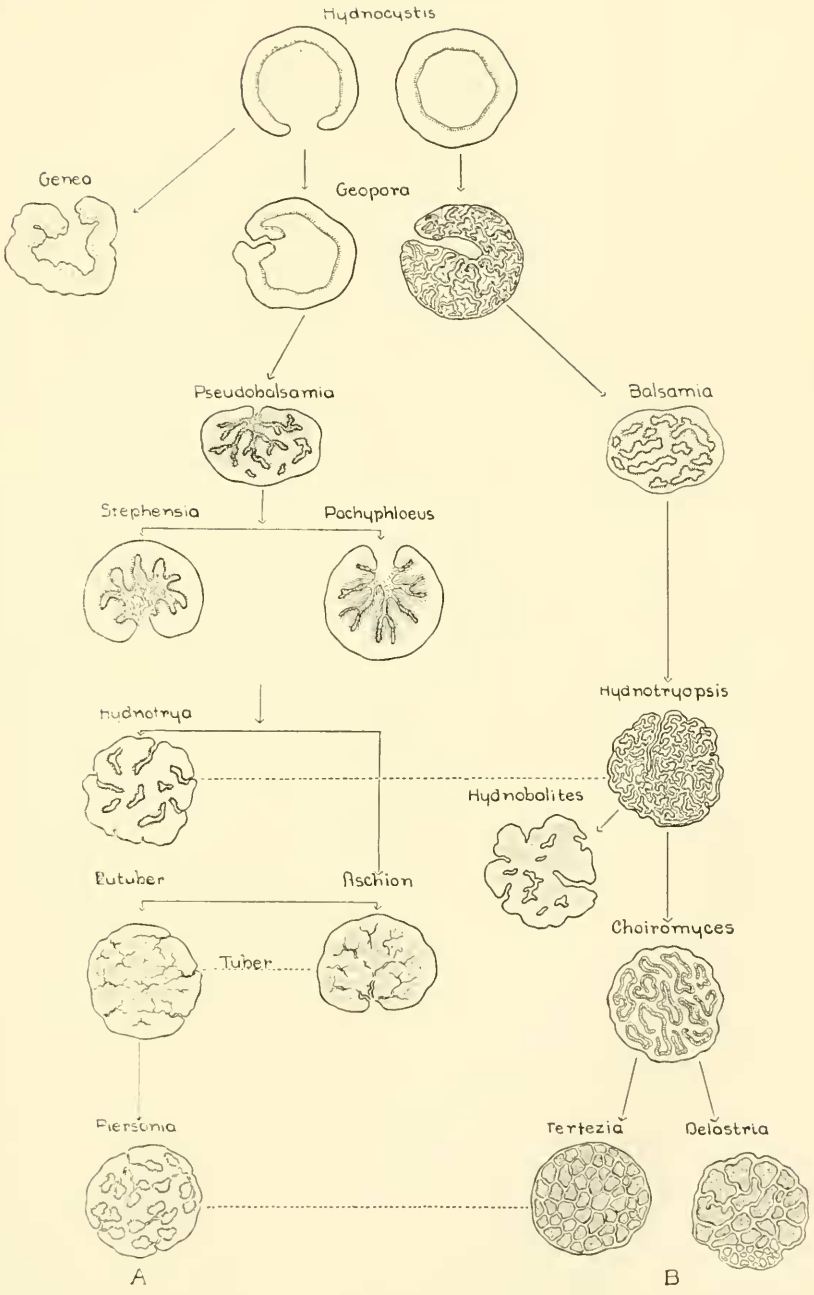
Hydnocystis
Genea
Geopora
Pseudobalsamia
Balsamia
Stephensia
Pachyphloeus
Hydnotrya
Hydnotryopsis
Hydnobolites
Rutuber
Aschion
Tuber
Choiromyces
Piersonia
Tertezia
Delastria
A
B

PLATE 27

Tuber candidum Hk.

Portion of ascocarp in section. × 500 diam.

a. Cortex.

b. Vena interna.

c. Vena externa.

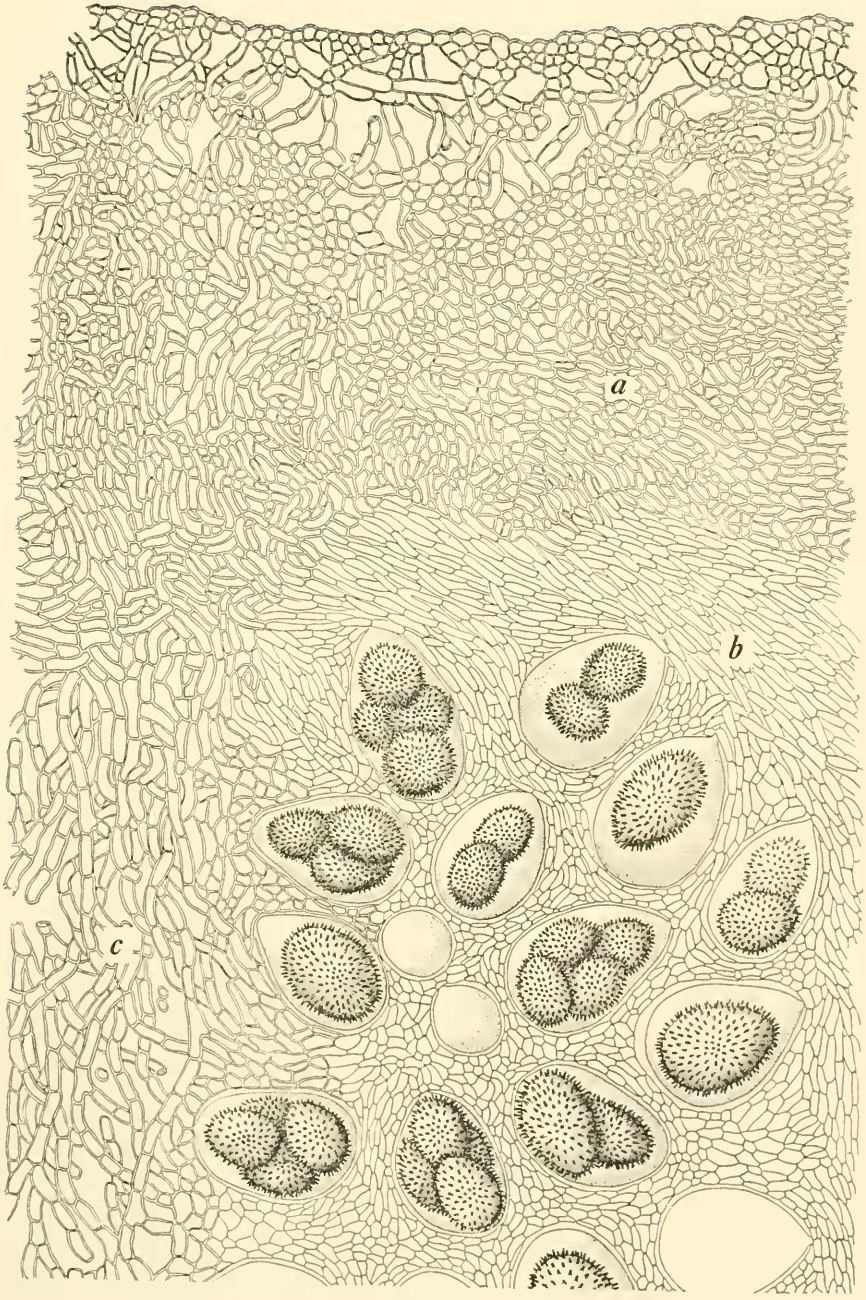
a
b
c

PLATE 28

Fig. 1. Ascus and spores of *Piersonia alveolata*. × 500 diam.

Fig. 2. Ascus and spores of *Piersonia alveolata* (*Piersonia scabrosa* Hk.). × 500 diam.

Fig. 3. Ascus and spores of *Piersonia alveolata* (*Pachyphloeus ligericus* Hk.). × 500 diam.

Fig. 4. Spores of *Piersonia alveolata* (*Hydnobolites excavatum* Hk.). × 500 diam.

Fig. 5. Ascus and spores of *Piersonia bispora* sp. nov. × 500 diam.

Fig. 6. Ascus and spore of *Geopora annulata* sp. nov. × 350 diam.

Fig. 7. Ascus and spore of *Genea Gardneri* sp. nov. × 400 diam.

Fig. 8. Paraphyses of *Genea Gardneri*. × 400 diam.